

Workshop on Proactive AIOps through Digital Twins

4 Pathways to Autonomic Software Evolution Through Digital Twin



MIGUEL JIMENEZ

PhD Candidate
University of Victoria

Miguel Jiménez, Luis F. Rivera, Norha M. Villegas,
Gabriel Tamura, Hausi A. Müller

#CXEtechconf

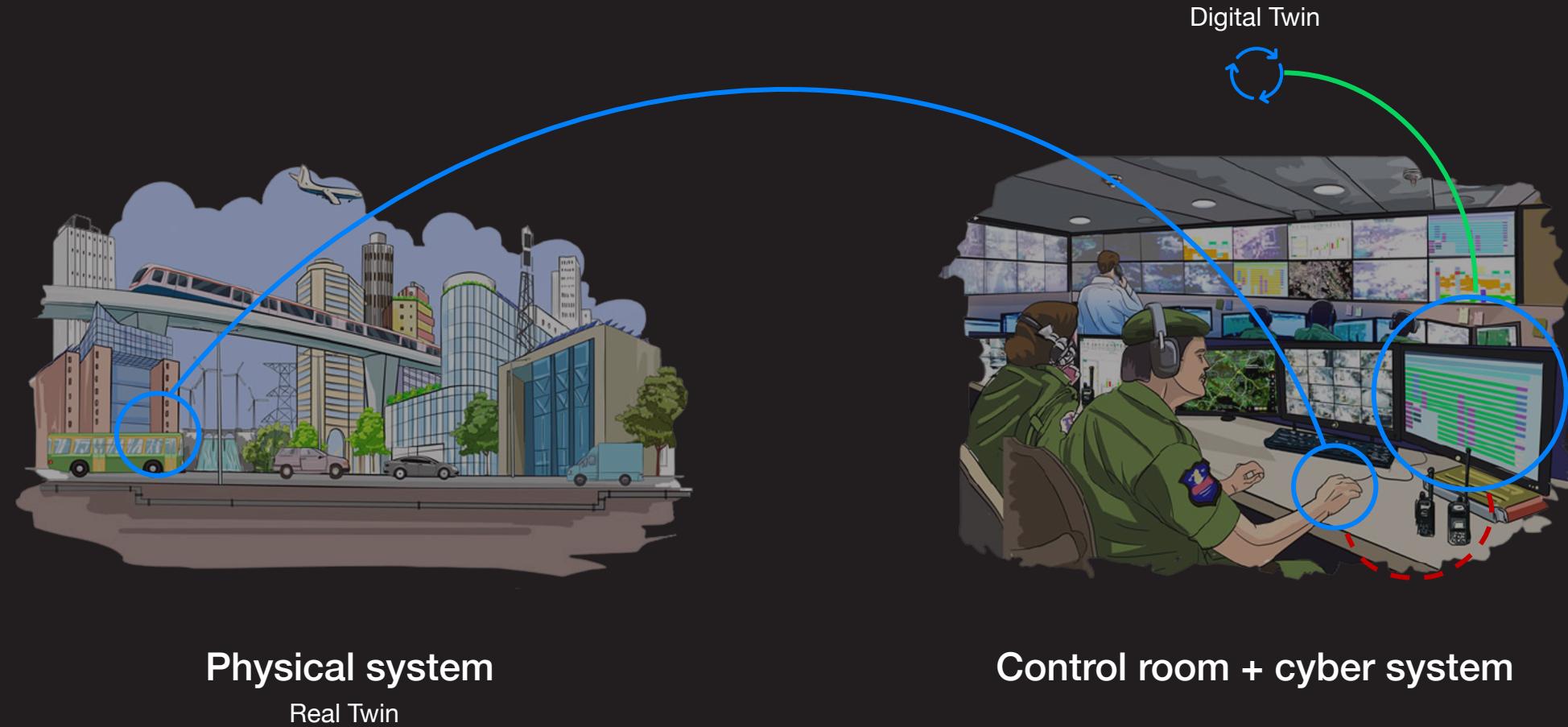


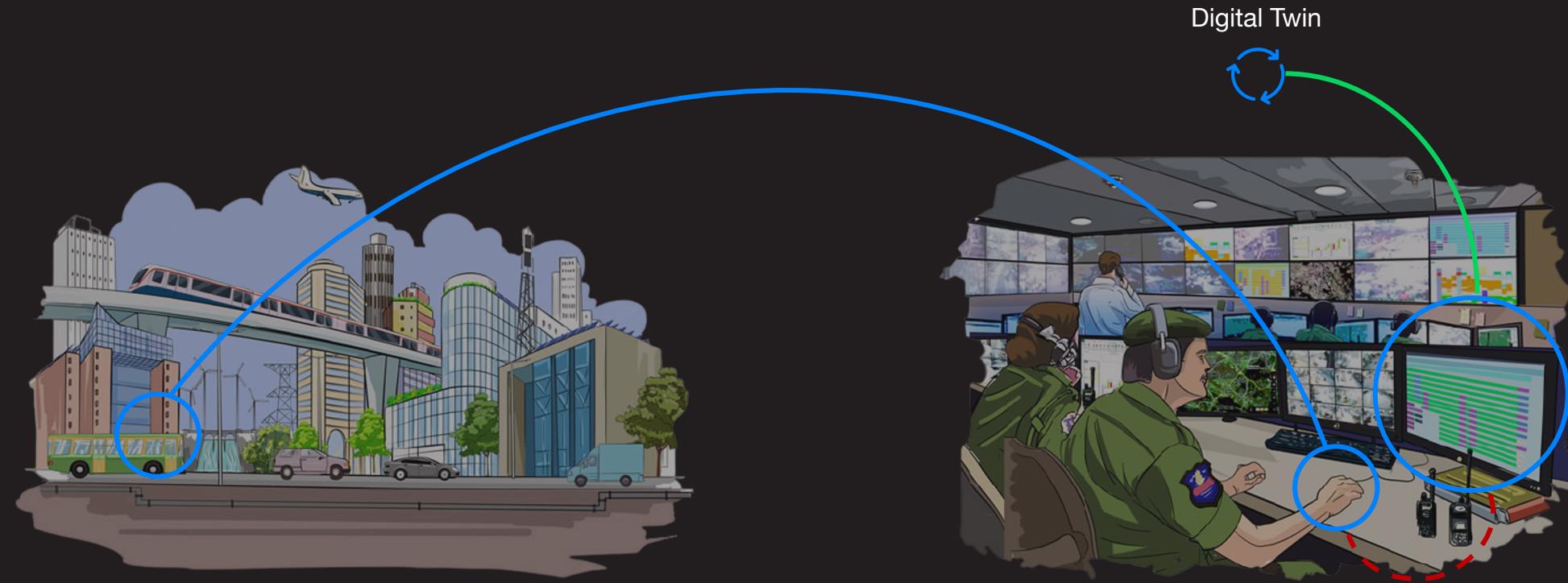


Physical system



Control room + cyber system





Software system

Software Twin

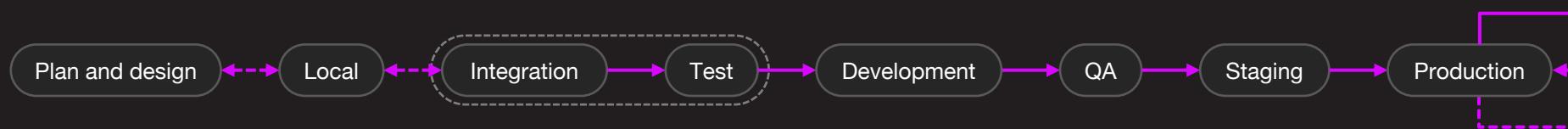
IT Operations / Development

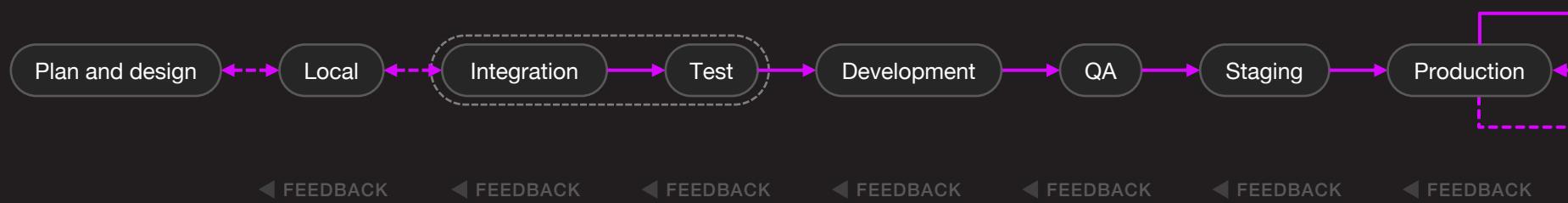
4 Pathways to Autonomic Software Evolution

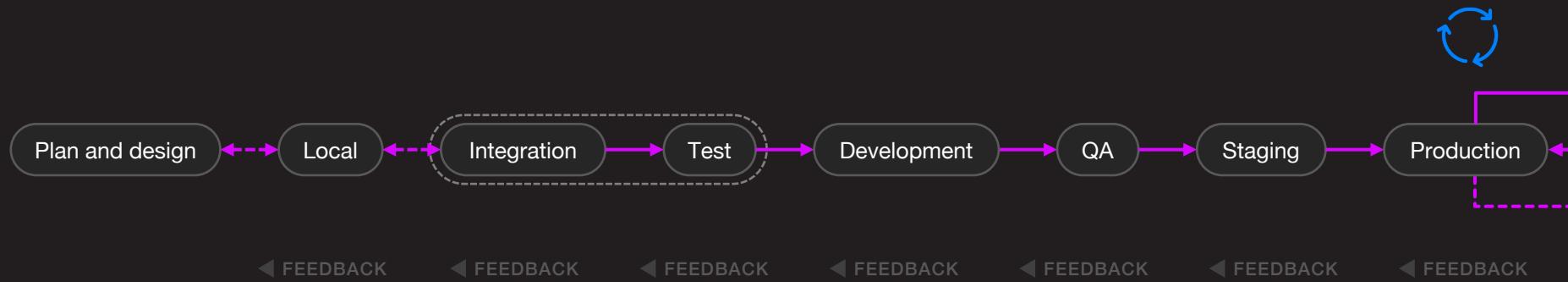


CASCON

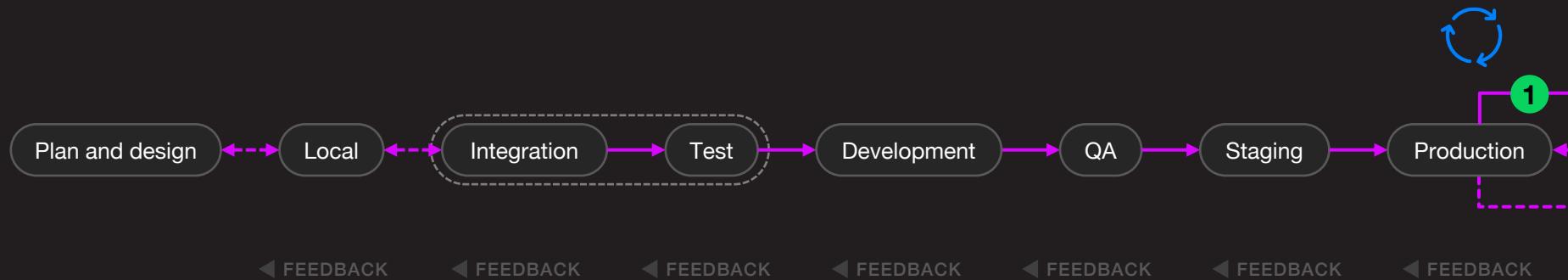
EVO
KE



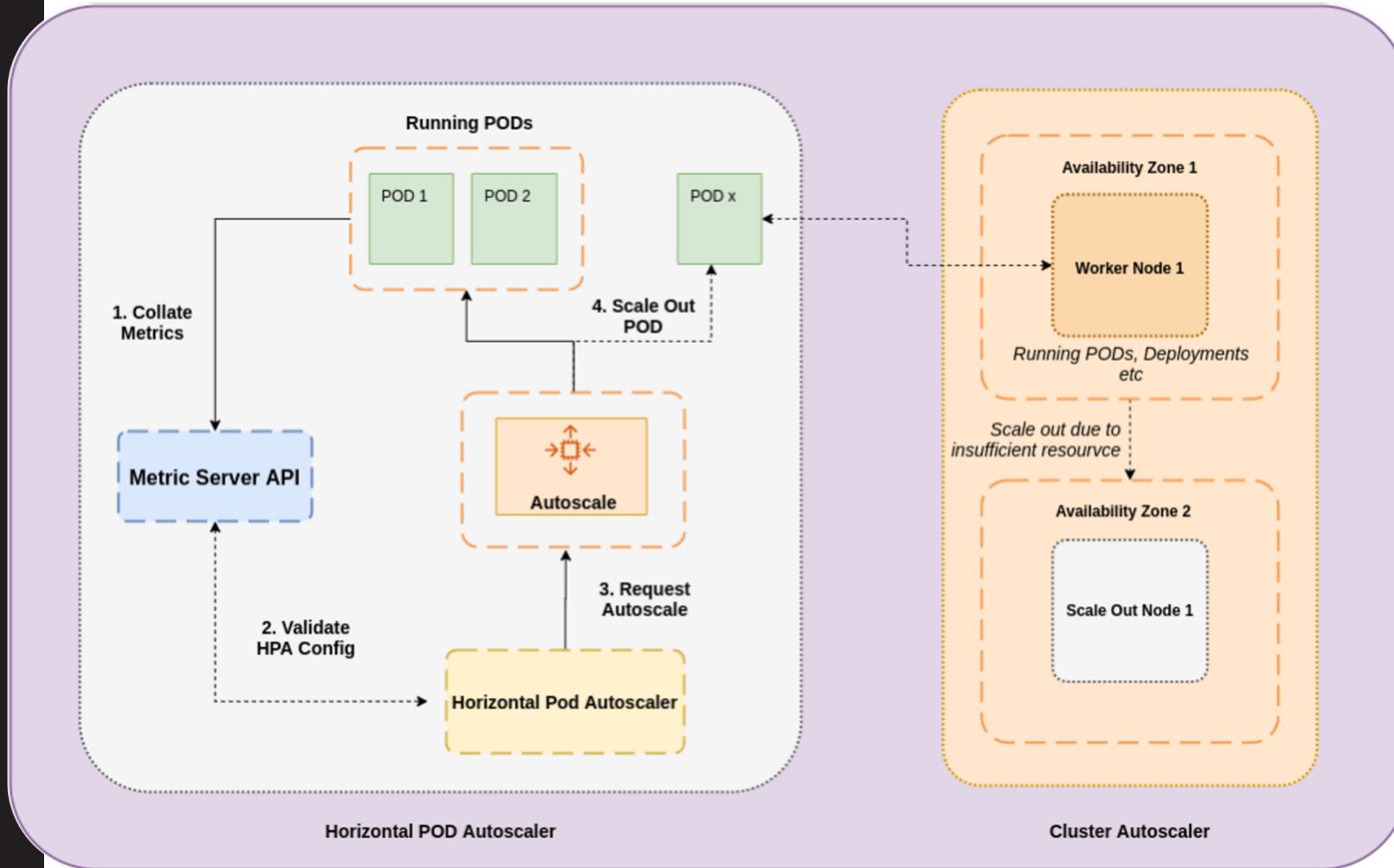




1 Self-management



Example



Self-managed vertical and horizontal scalability

Kubernetes Autoscaler

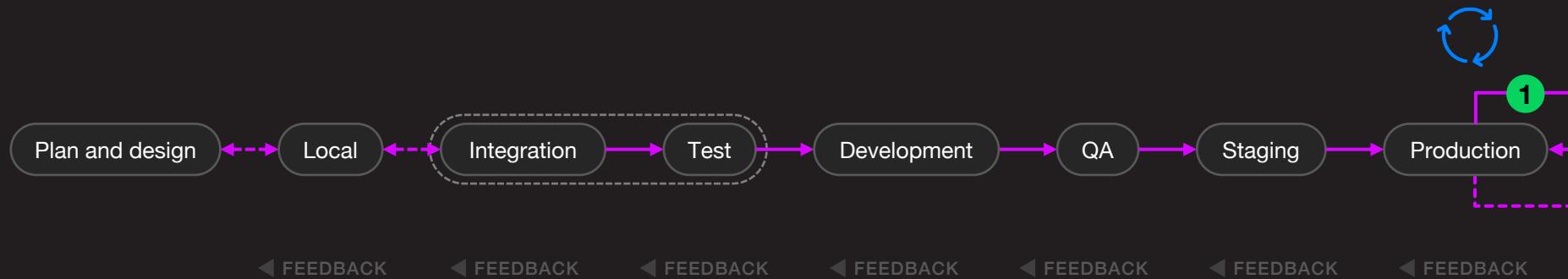
Example



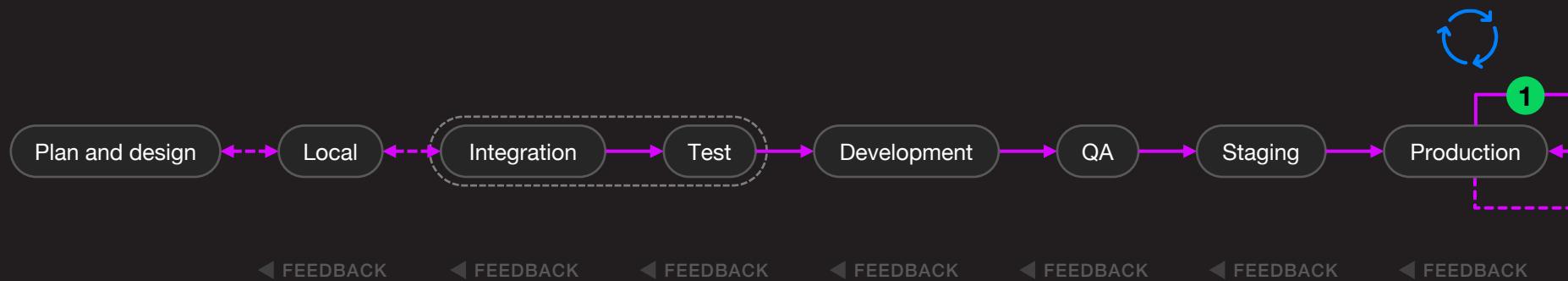
Self-managed deployment rollback (self-healing)

Spinnaker Deployment Strategies

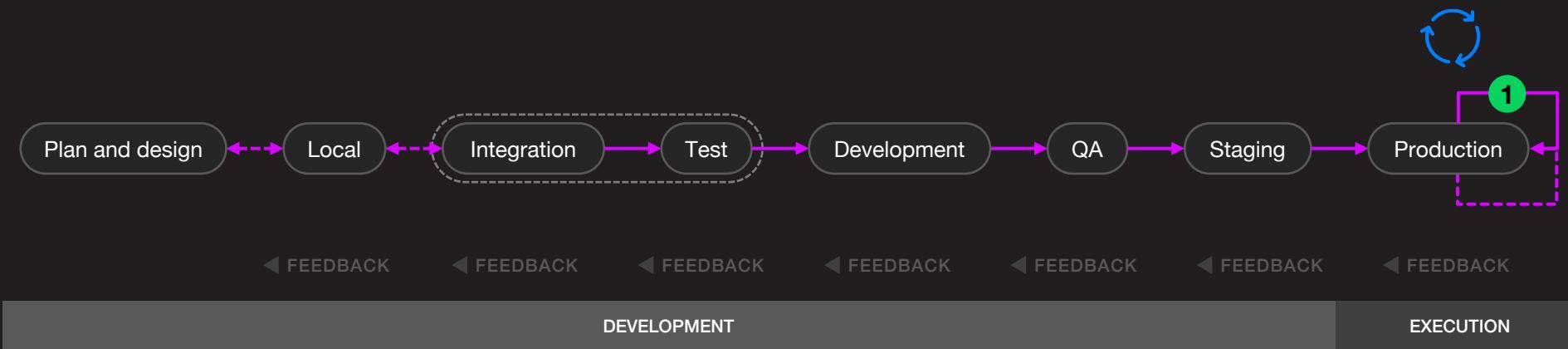
1 Self-management



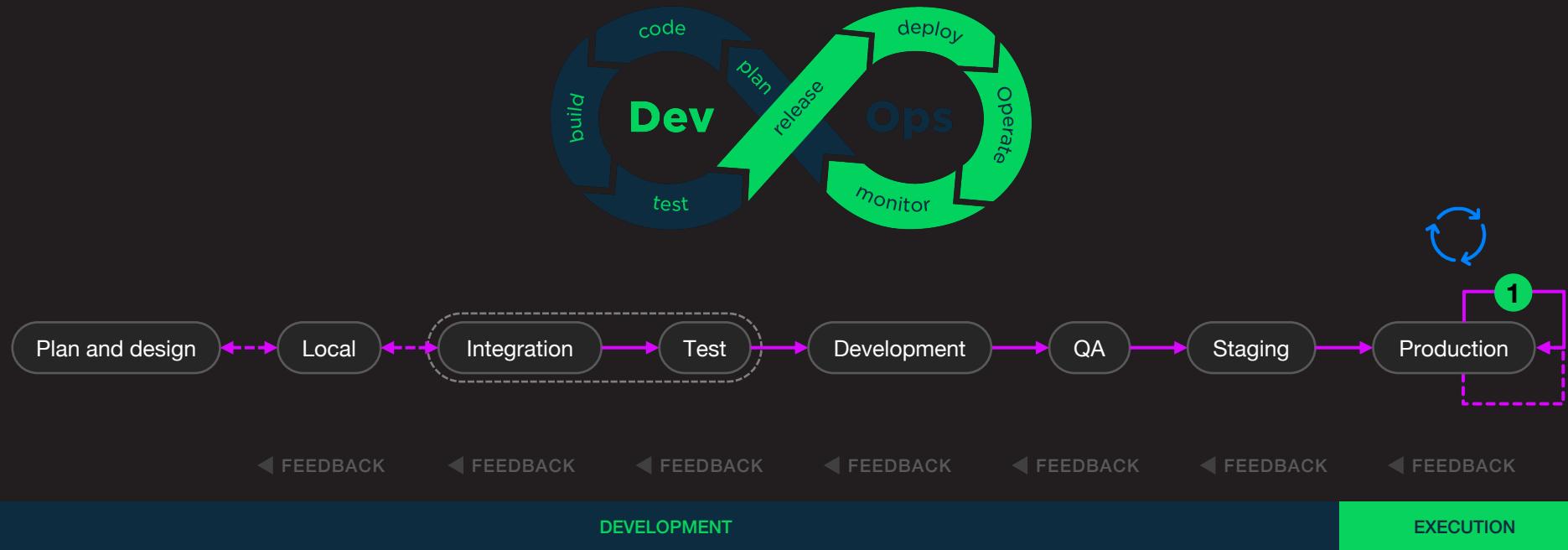
① Self-management



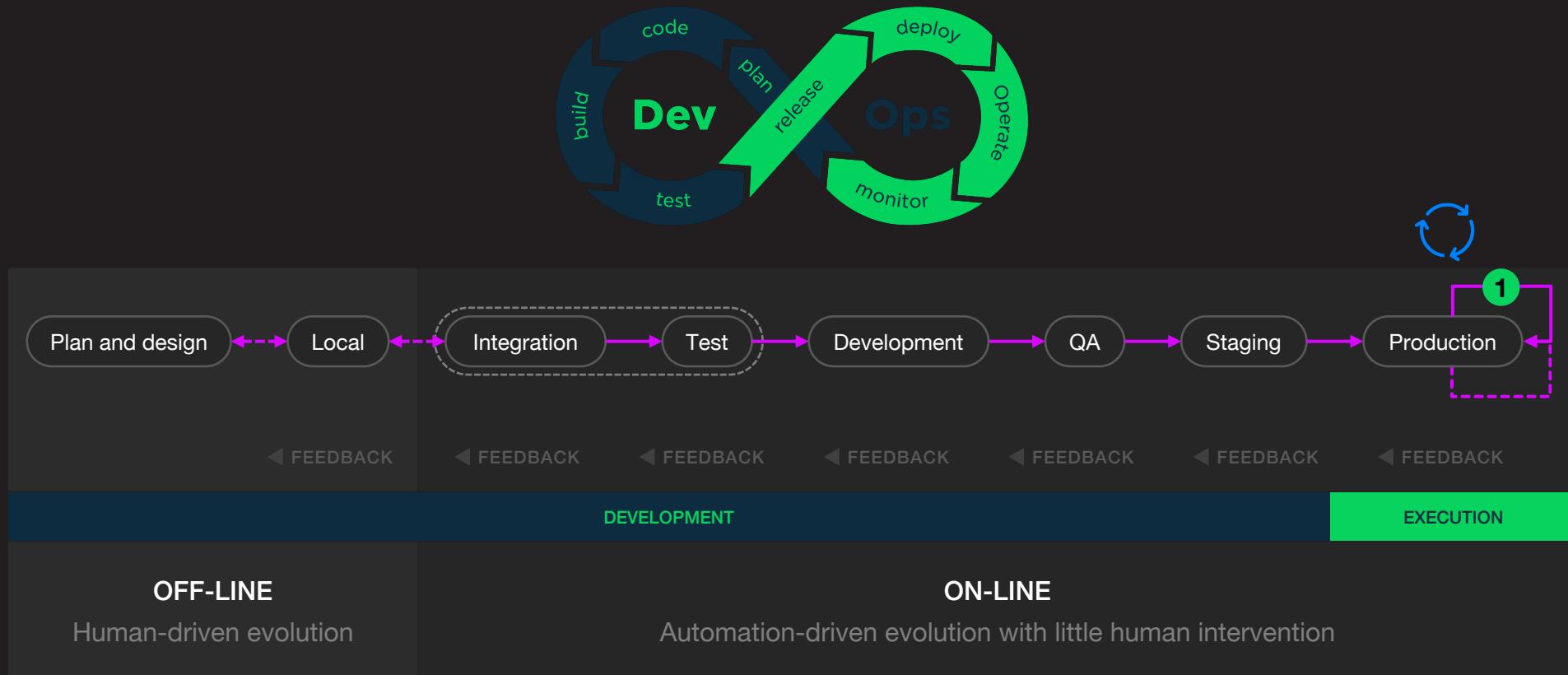
1 Self-management



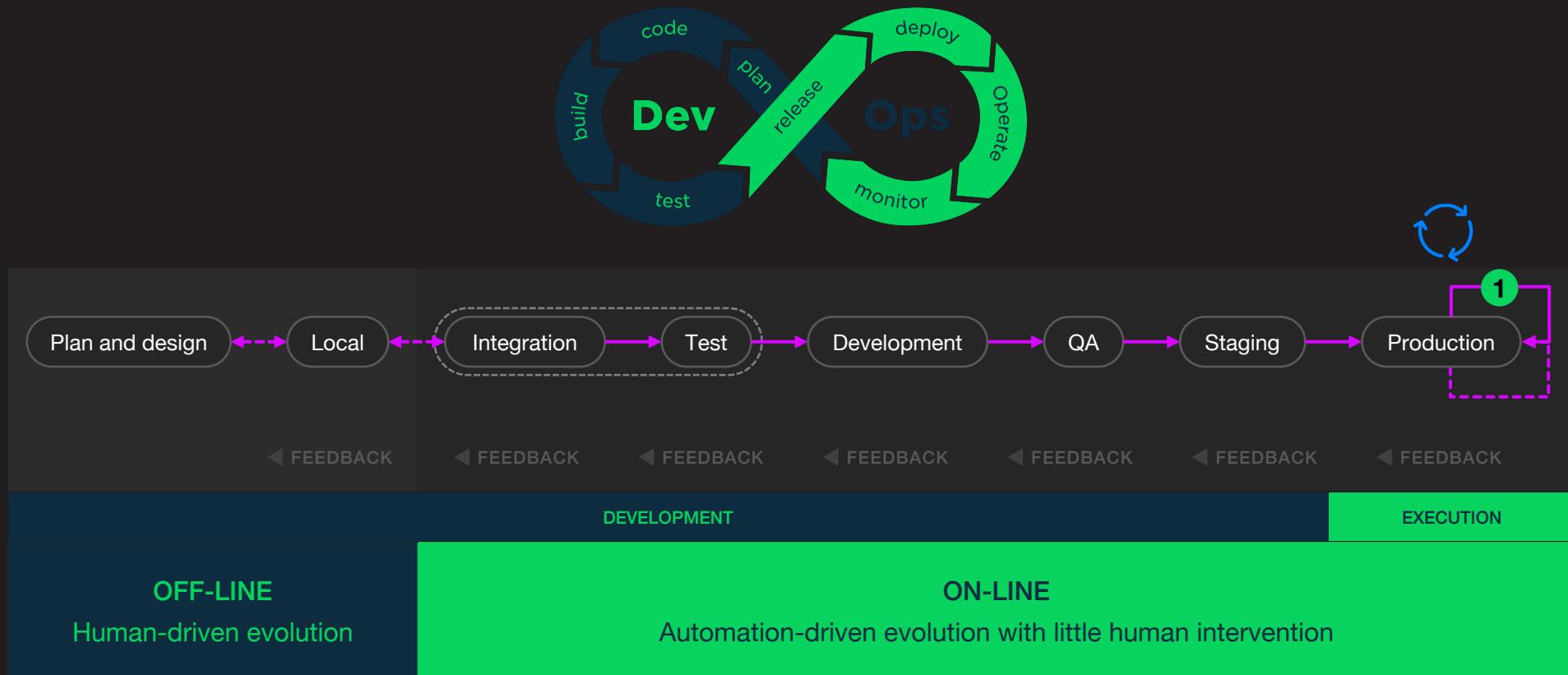
1 Self-management



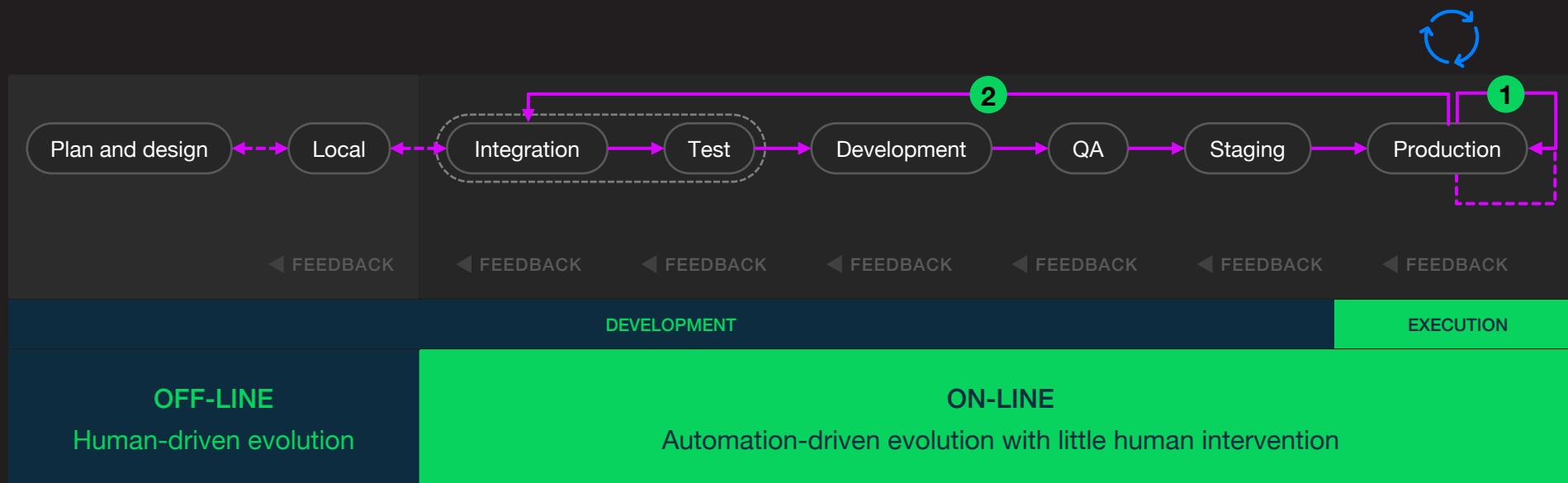
1 Self-management



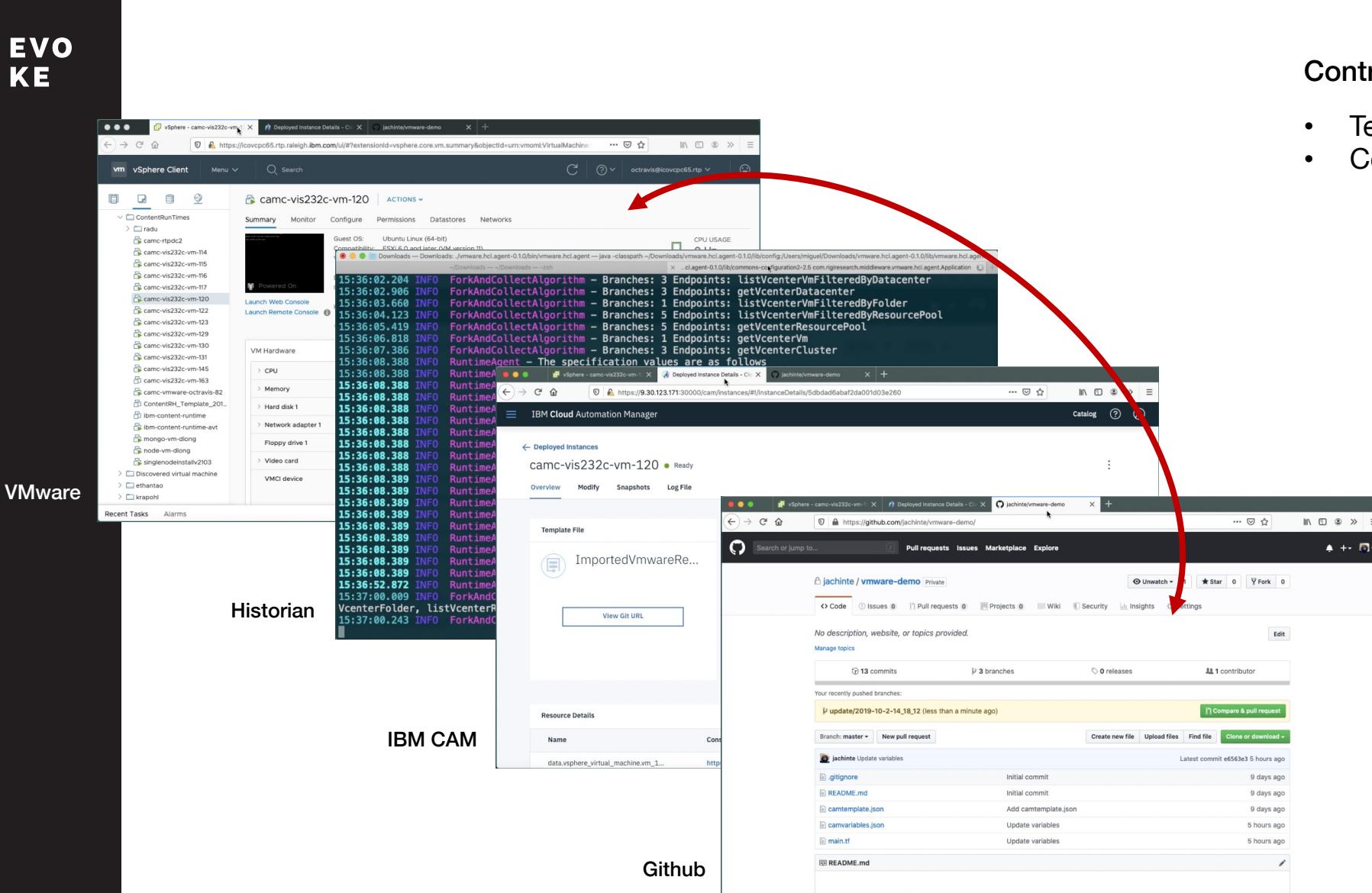
1 Self-management



- ① Self-management
- ② Self-evolution



Example



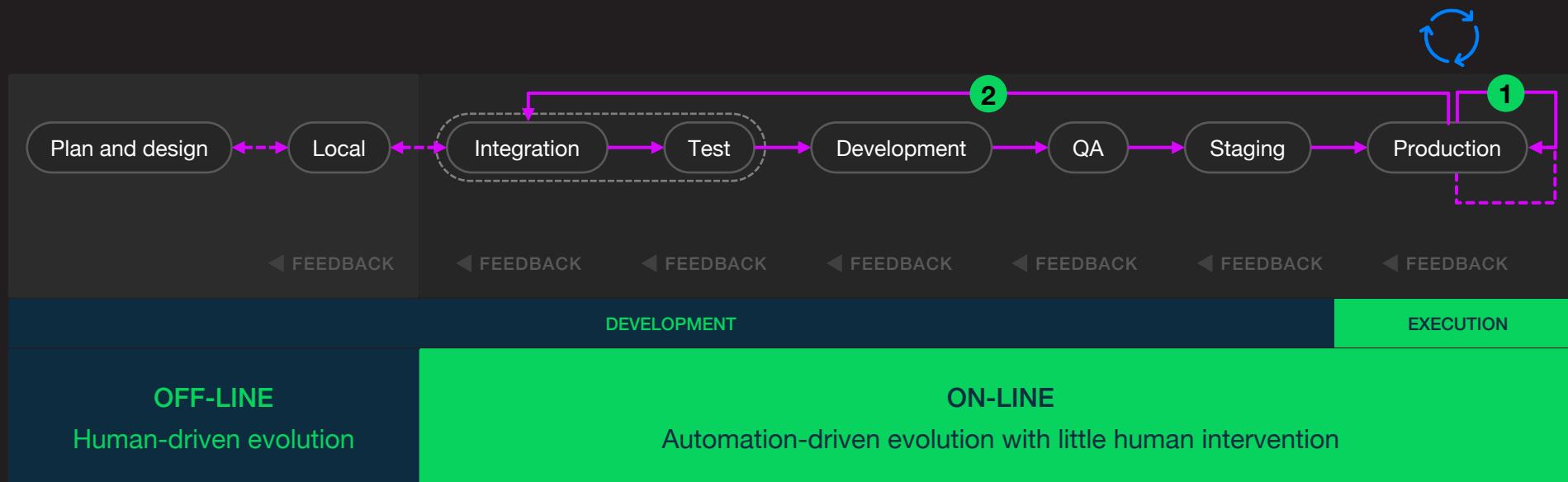
Continuous Evolution of Infrastructure-as-Code Specifications

Not published yet – In the process of being patented

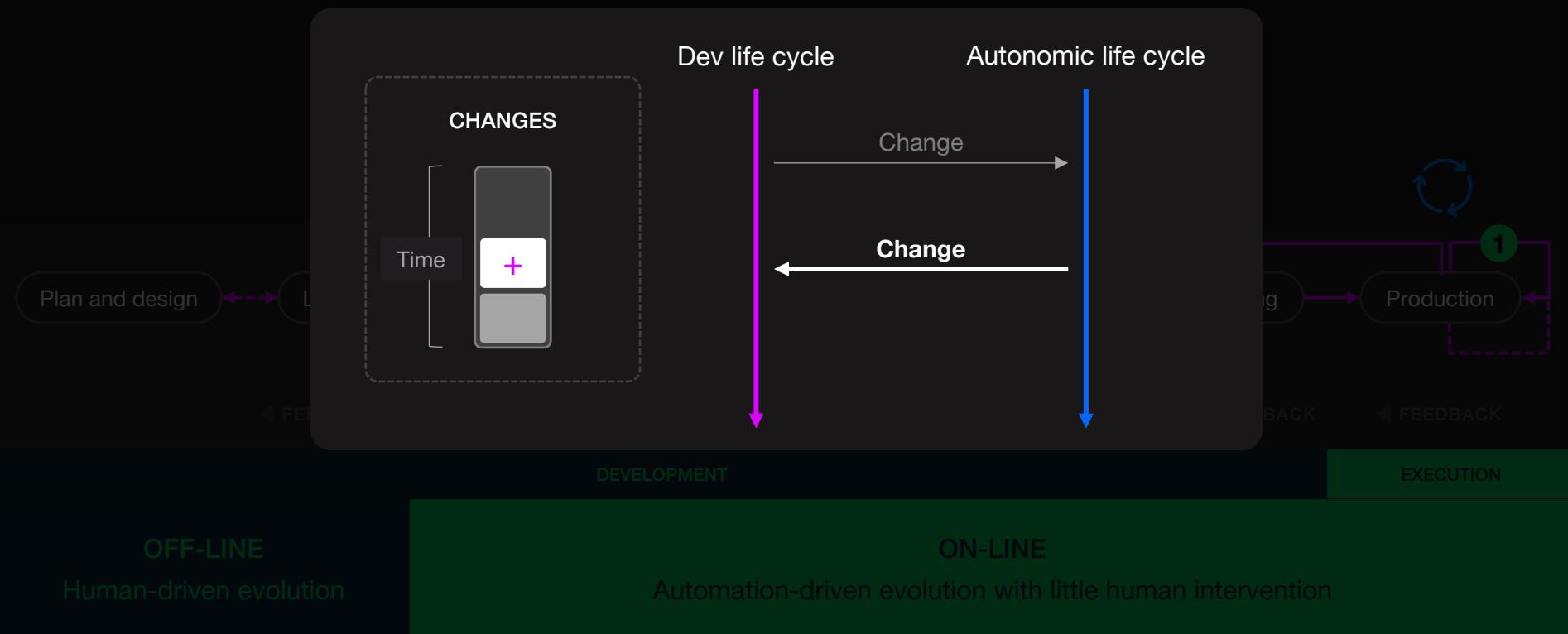
Contributes to reduce

- Technical debt
- Configuration drift

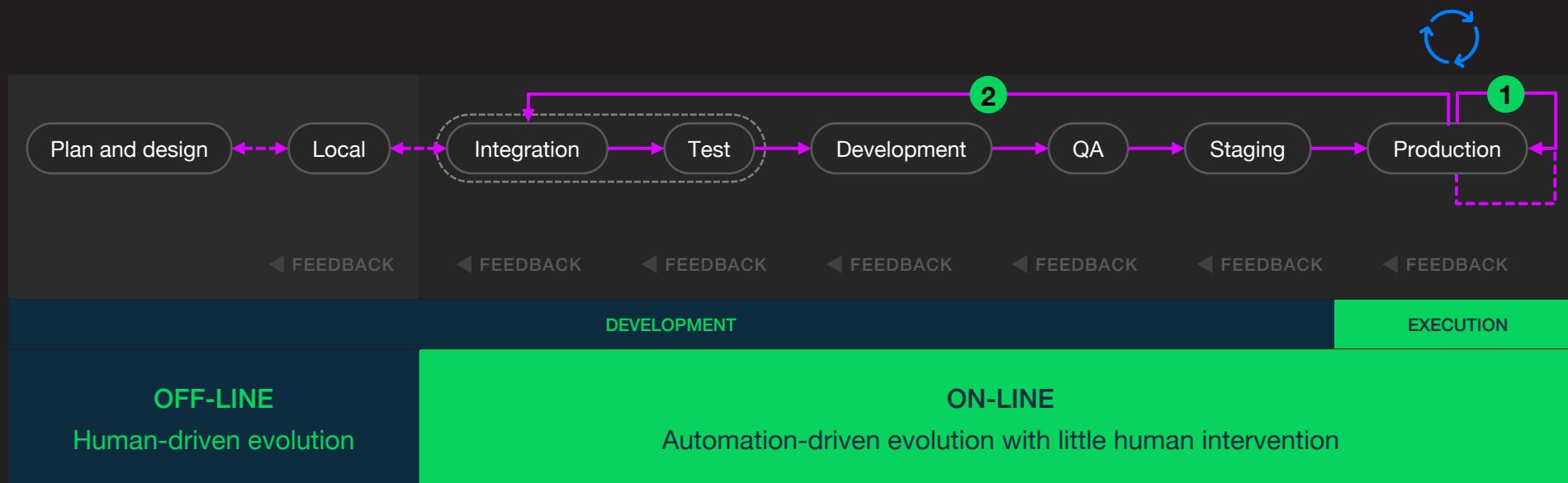
- 1 Self-management
- 2 Self-evolution



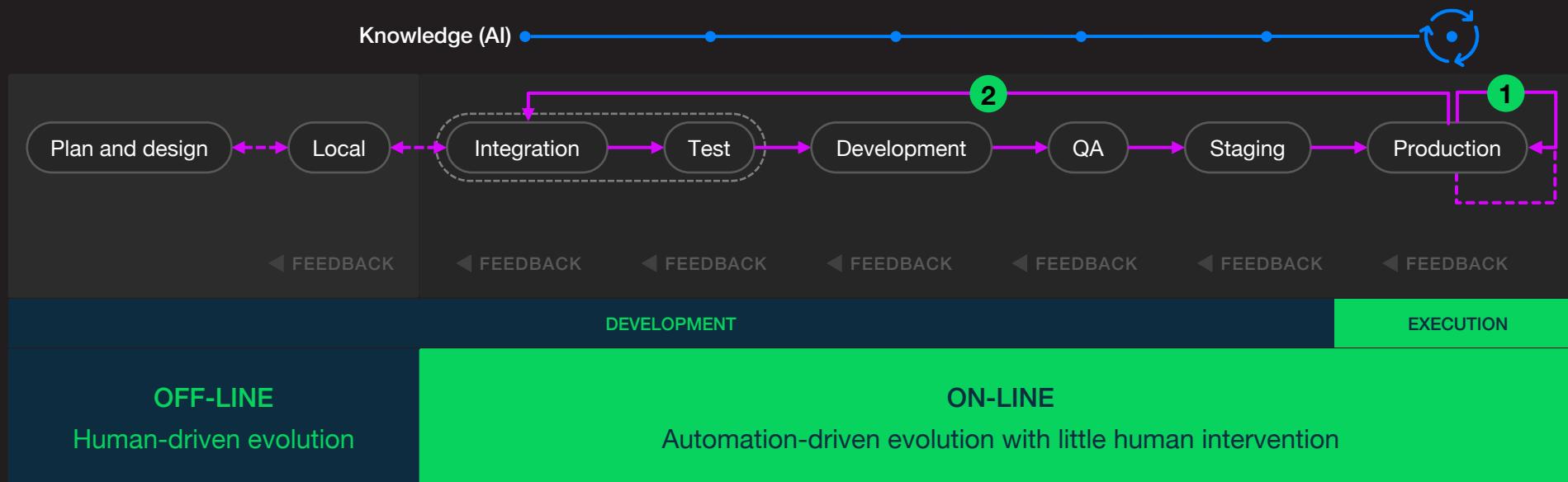
- 1 Self-management
- 2 Self-evolution



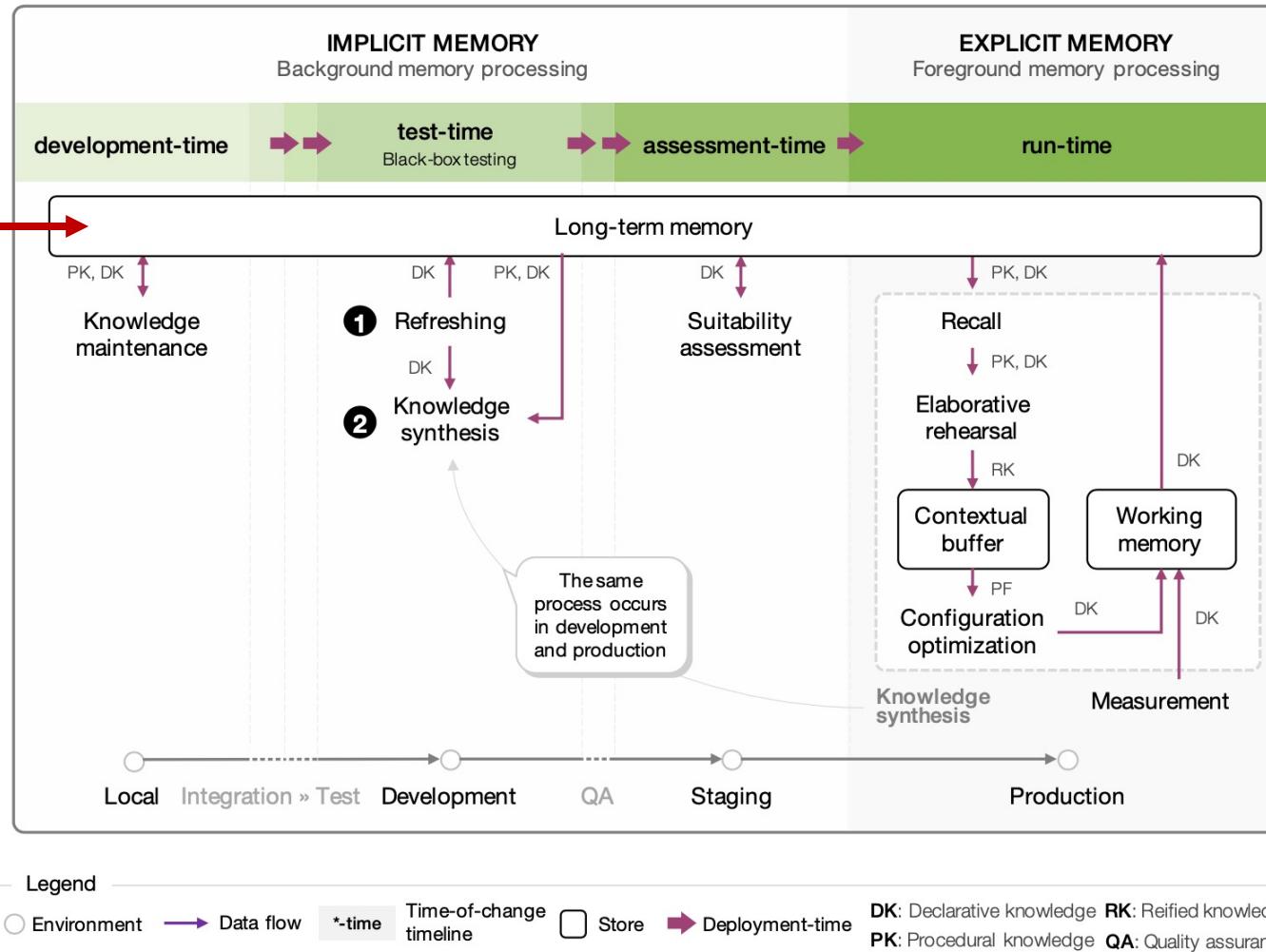
- 1 Self-management
- 2 Self-evolution



- ① Self-management
- ② Self-evolution



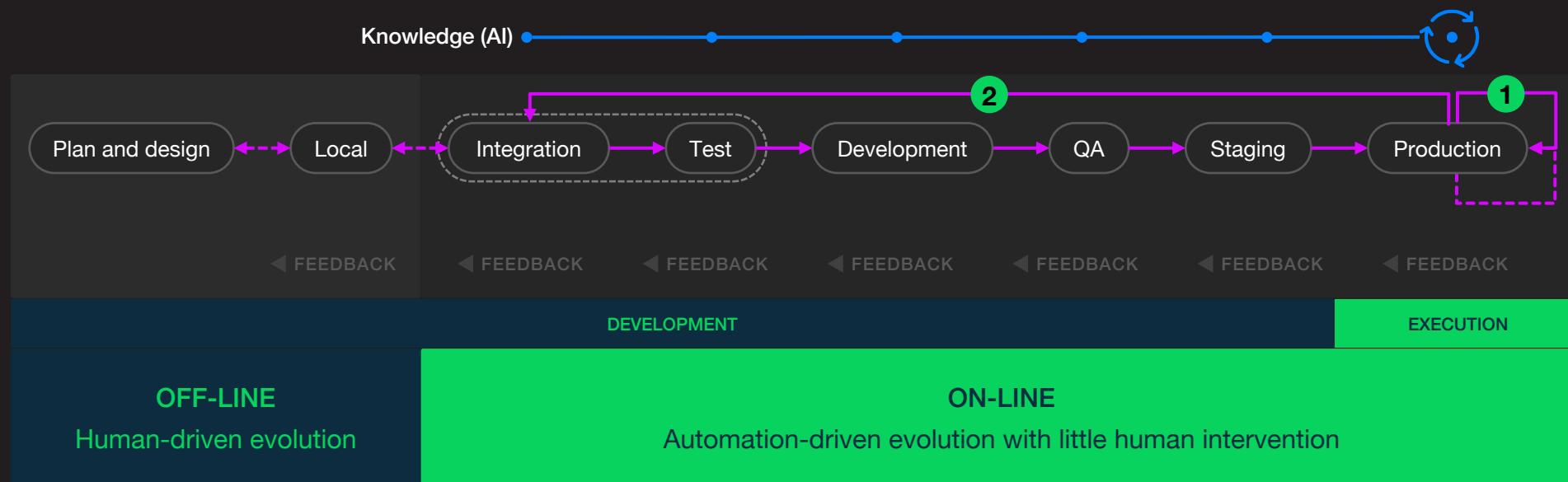
Example



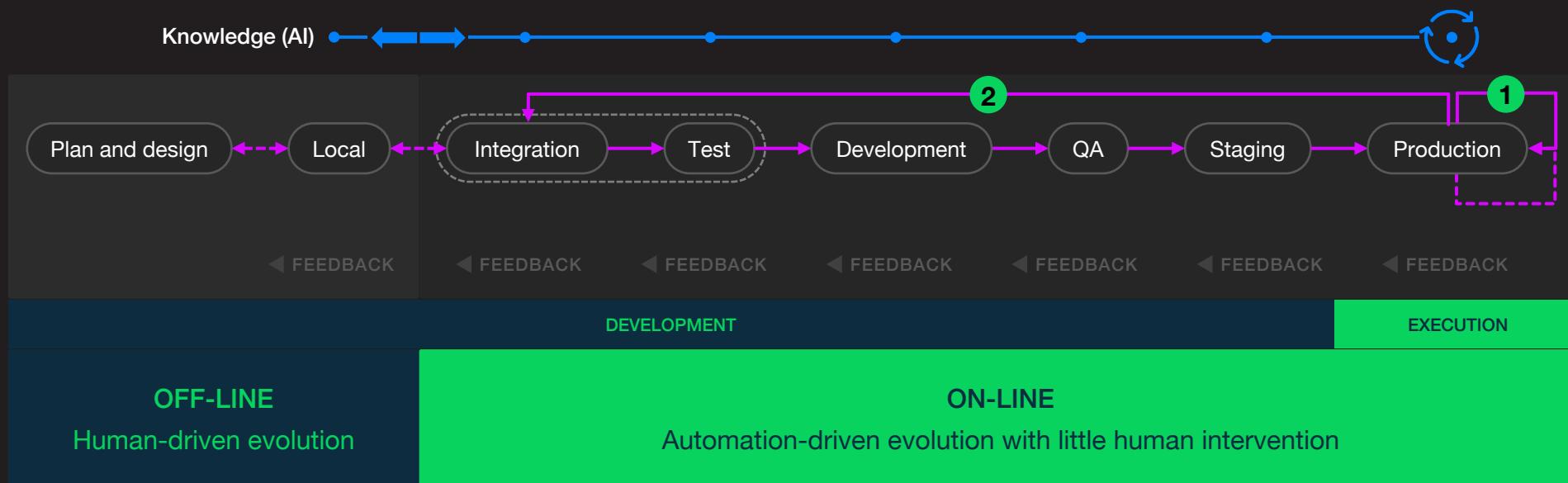
Learning processes throughout the software development life cycle

Not published yet

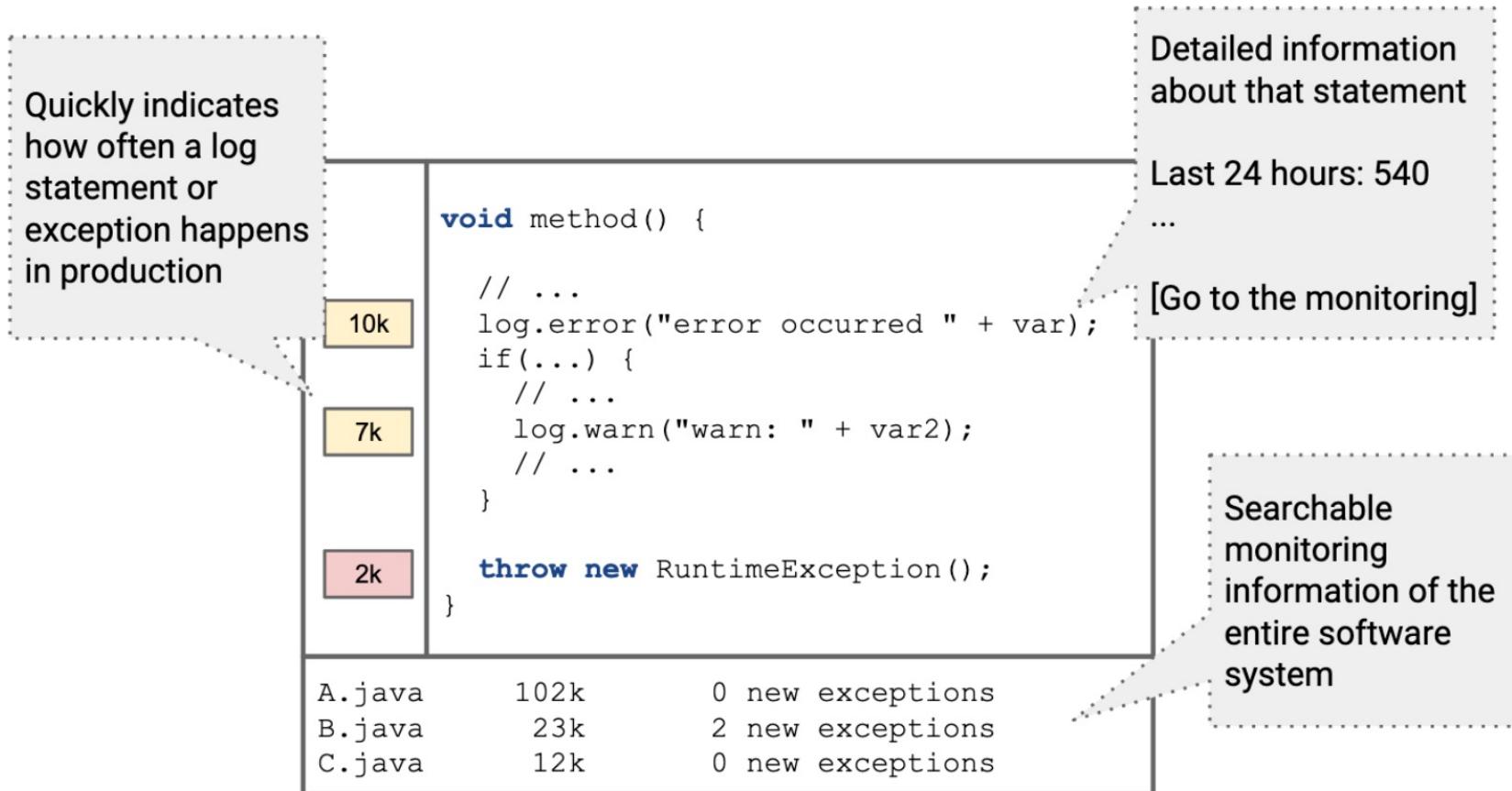
- ① Self-management
- ② Self-evolution



- ① Self-management
- ② Self-evolution



Example



Monitoring-aware IDEs

Winter et al. "Monitoring-aware IDEs." 2019

Example

```

@Transactional(readOnly = true)
public List<StoryTO> retrieveLeafStories(int projectId, StoryFilters filters) {
    Project original = this.retrieve(projectId);

    List<Story> leafStories = this.st
        The Method retrieve has been identified as critical.
        The average execution time is: 98.723ms.

    leafStories = storyFilterBusiness
    List<StoryTO> leafStoriesWithRank
    int rank = 0;
    for(Story leafStory : leafStories
        StoryTO tmp = new StoryTO(leafStory);
        tmp.setRank(rank++);

        Set<Task> tasks = new HashSet<Task>();
        for (Task task : tmp.getTasks()) {

            TaskTO taskTO = new TaskTO(task);
            long sum = 0;
            //TODO: sum up minutes from taskTO.getHourEntries and store it in task
            tasks.add(taskTO);

        }
        tmp.setTasks(tasks);
        leafStoriesWithRank.add(tmp);
    }
    return leafStoriesWithRank;
}

```

```

@Transactional(readOnly = true)
public List<StoryTO> retrieveLeafStories(int projectId, StoryFilters filters) {
    Project original = this.retrieve(projectId);

    List<Story> leafStories = this.storyRankBusiness.retrieveByRankingContext(original);

    leafStories = storyFilterBusiness.filterStoryList(leafStories, filters);
    List<StoryTO> leafStoriesWithRank = new ArrayList<StoryTO>();
    int rank = 0;
    for(Story leafStory : leafStories) {
        StoryTO tmp = new StoryTO(leafStory);
        tmp.setRank(rank++);

        Set<Task> tasks = new HashSet<Task>();
        for (Task task : tmp.getTasks()) {

            TaskTO taskTO = n
                long sum = 0;
                //TODO: sum up mi
                for(TaskHourEntry
                    sum += entry;
                }
                taskTO.setEffortS
                tasks.add(taskTO)
            }
            tmp.setTasks(tasks);
            leafStoriesWithRank.add(tmp);
        }
        return leafStoriesWithRank;
    }
}

```

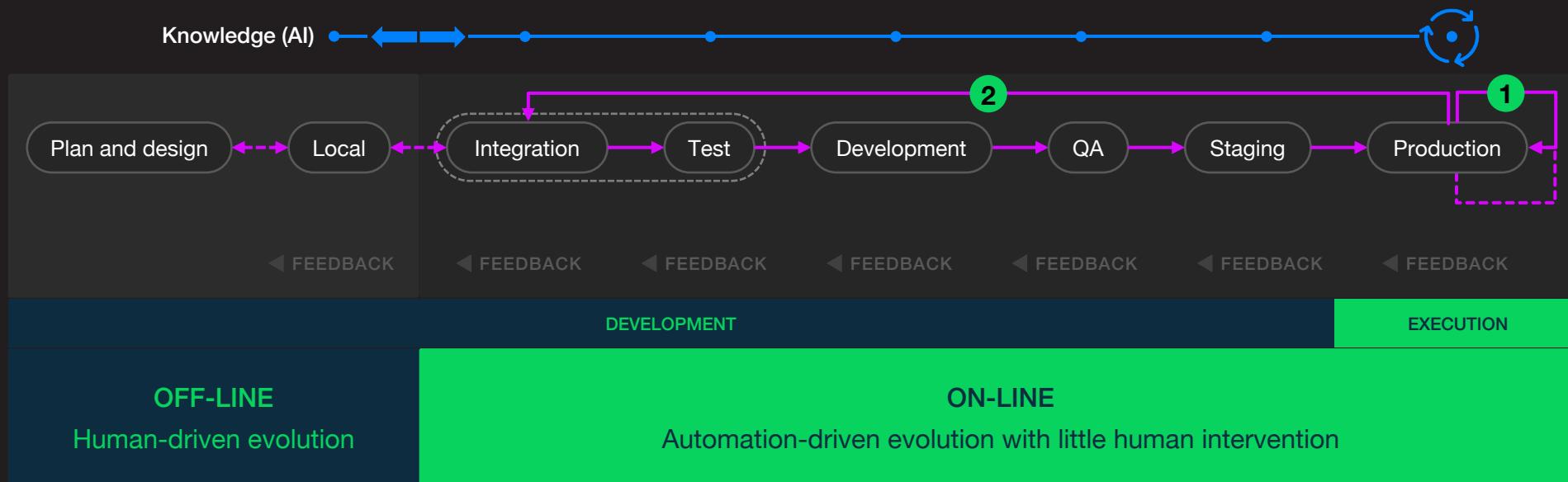
(a) Displaying Operational Footprint

(b) Inferring the Performance of Newly-Written Code

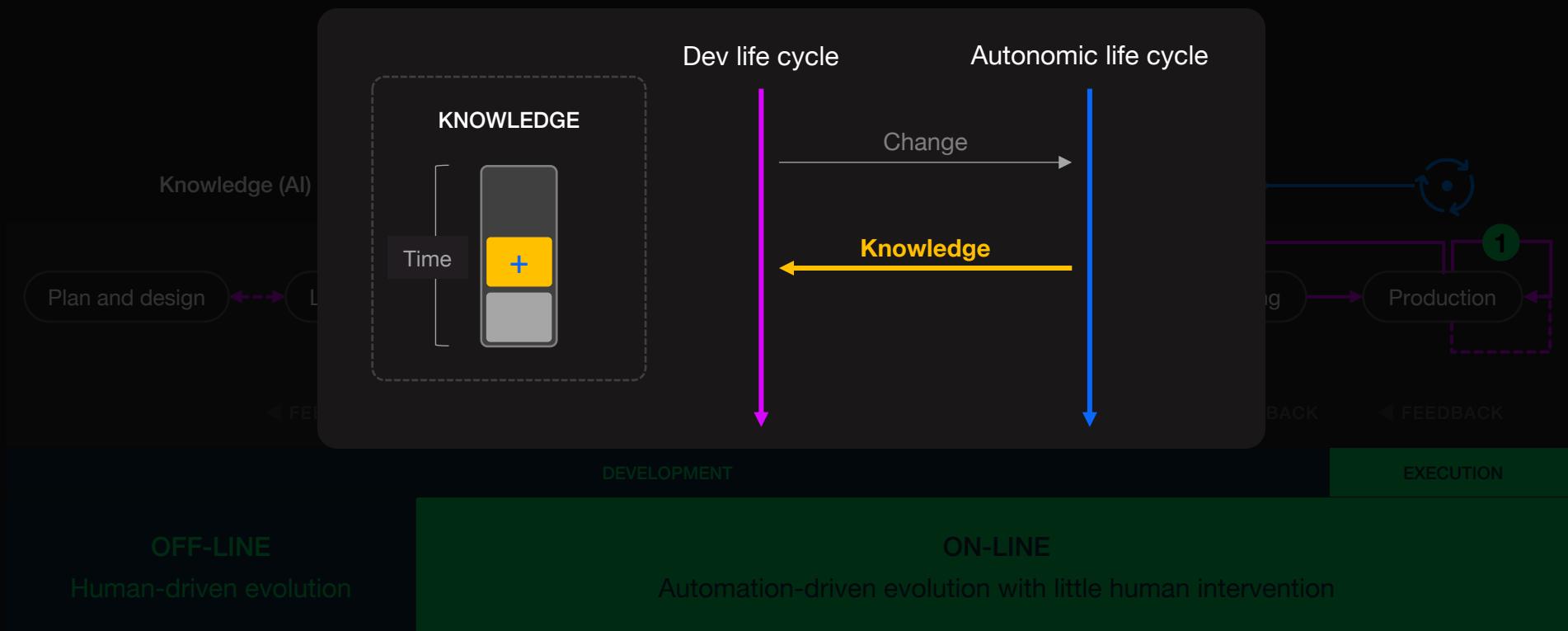
Performance Feedback in the IDE

Cito et al. "Interactive Production Performance Feedback in the IDE." 2019

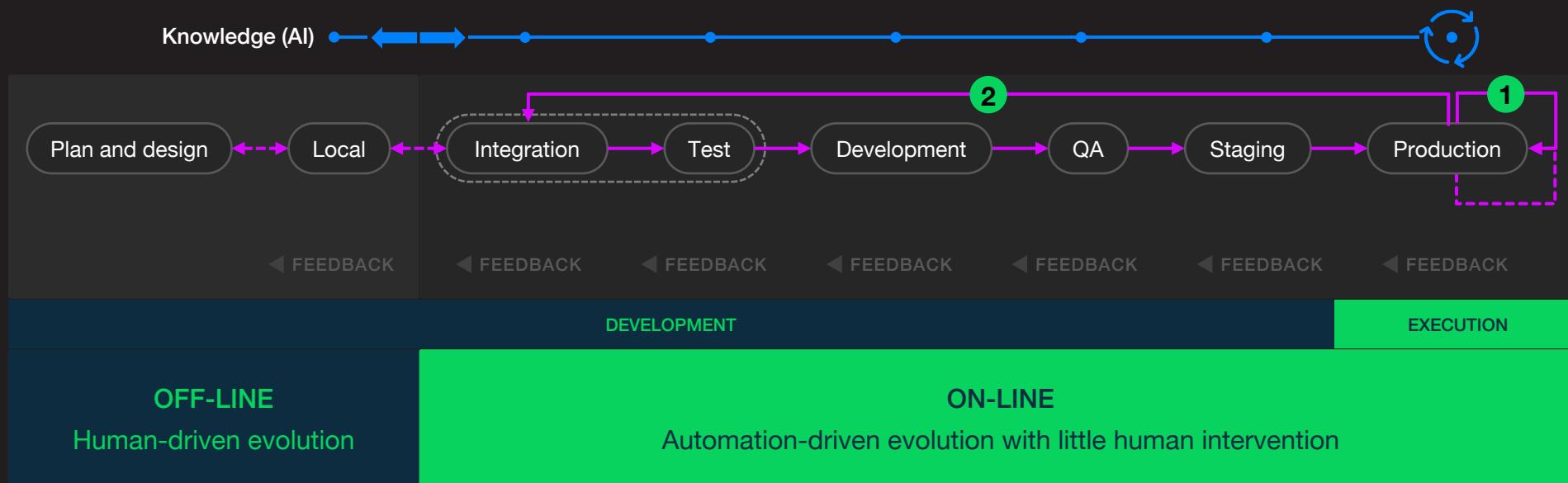
- ① Self-management
- ② Self-evolution



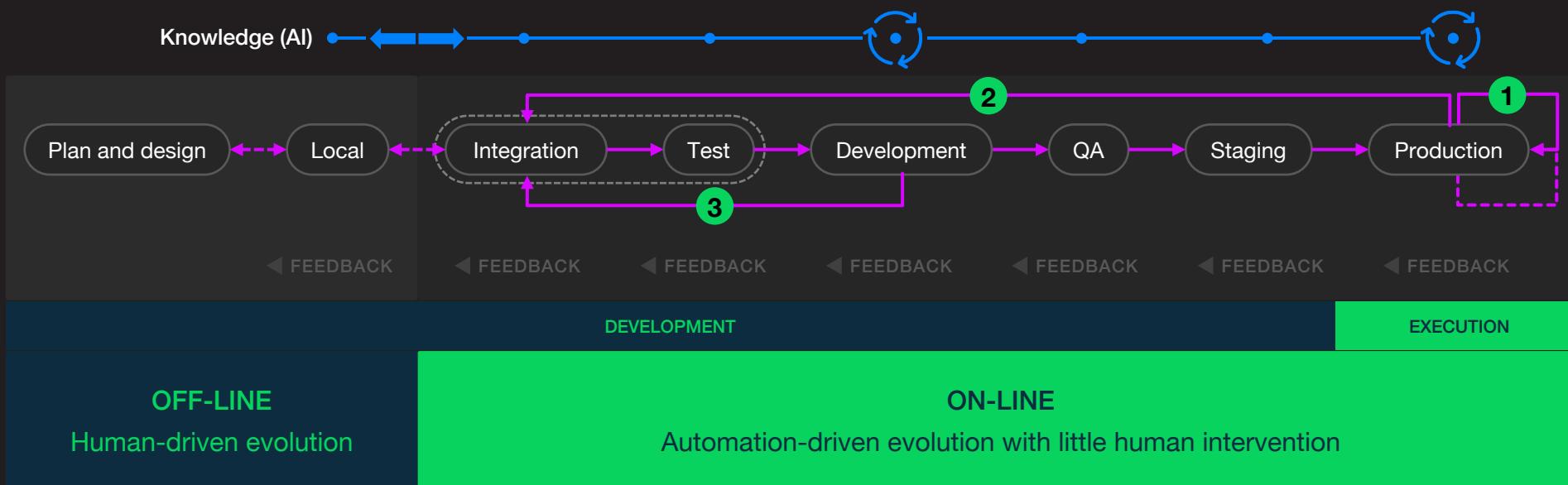
- 1 Self-management
- 2 Self-evolution



- ① Self-management
- ② Self-evolution



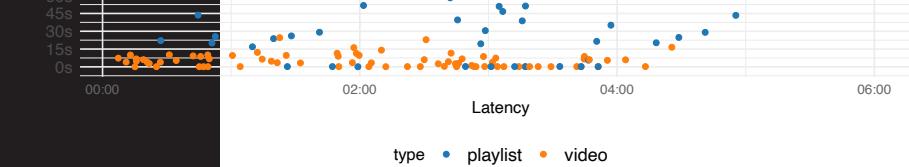
- 1 Self-management
- 2 Self-evolution
- 3 Self-improvement



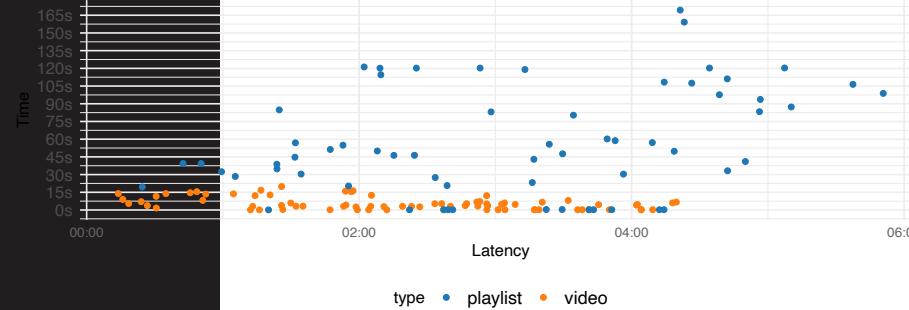
Example

linear-config1

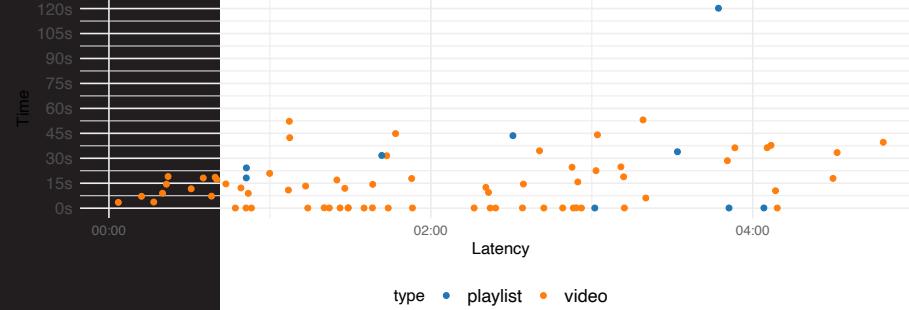
Latency Type



linear-config2

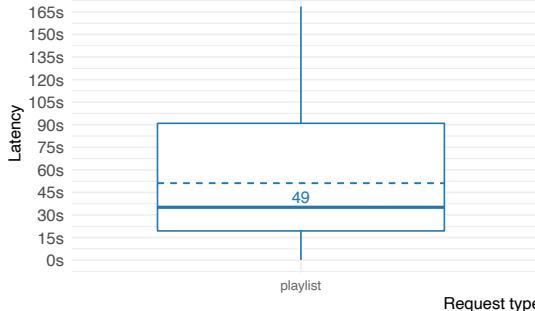


linear-config3

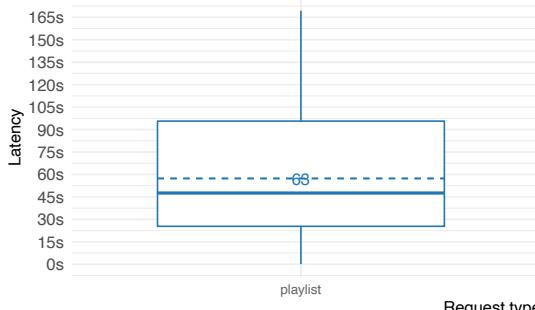


Latency Box

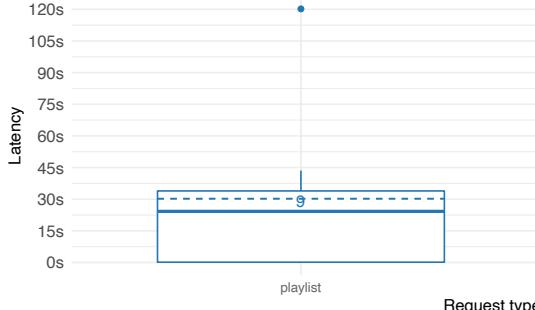
linear-config1



linear-config2



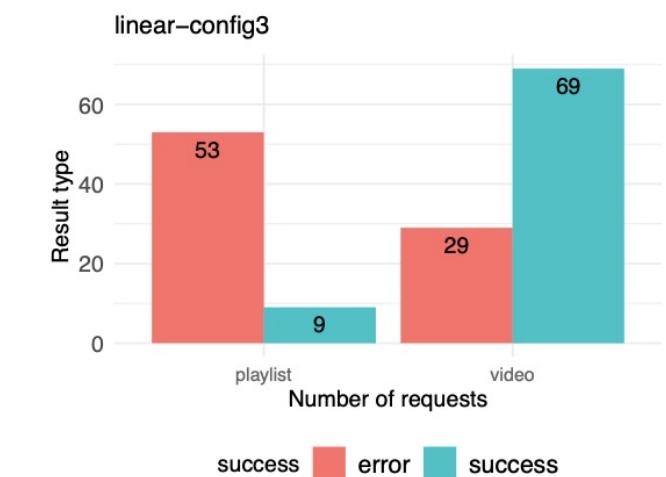
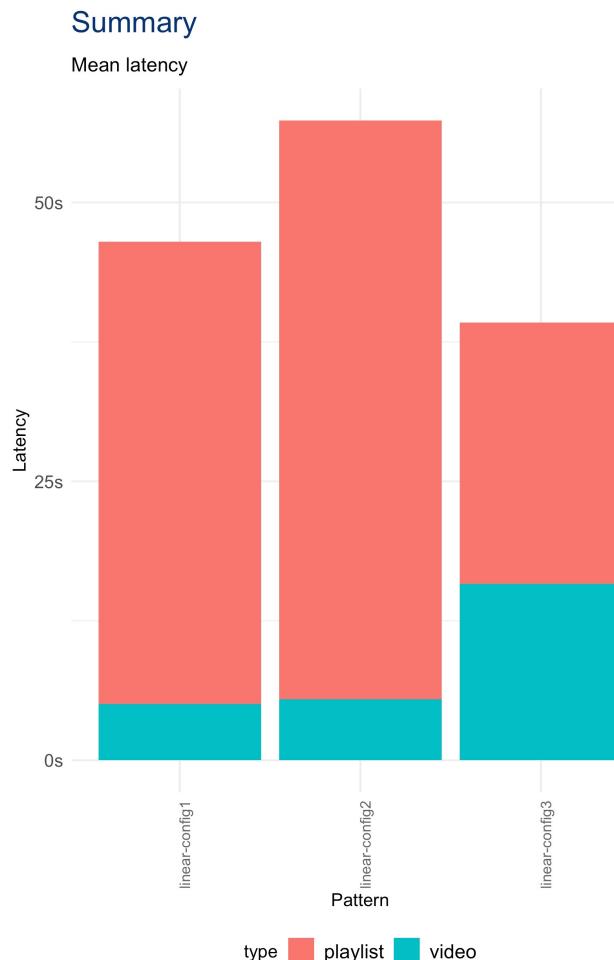
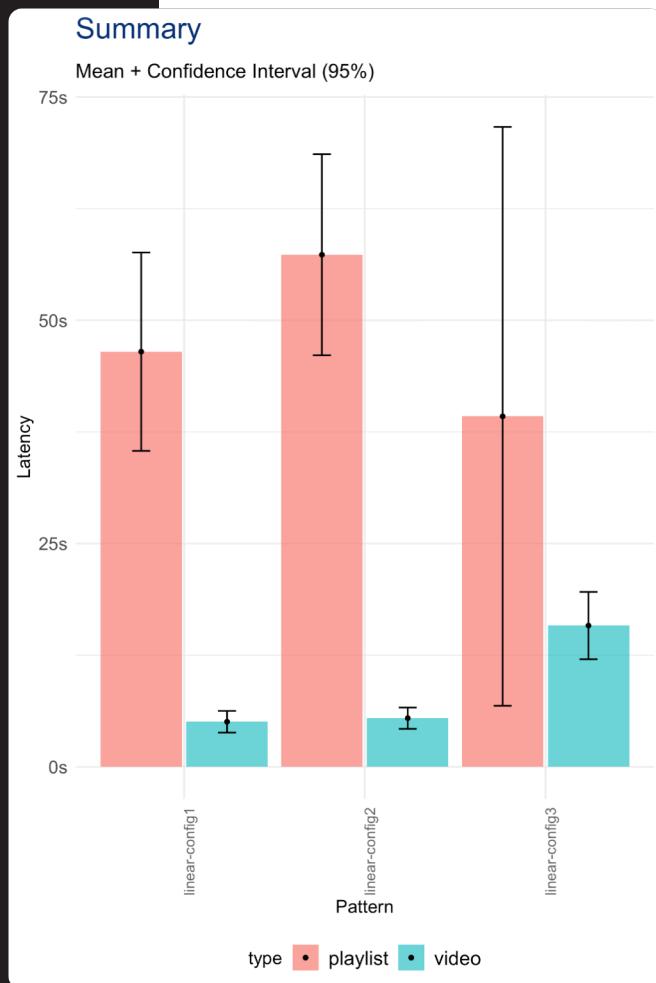
linear-config3



Automated Search Space Exploration Through Continuous Experimentation

Not published yet

Example

**Config 3 - Errors**

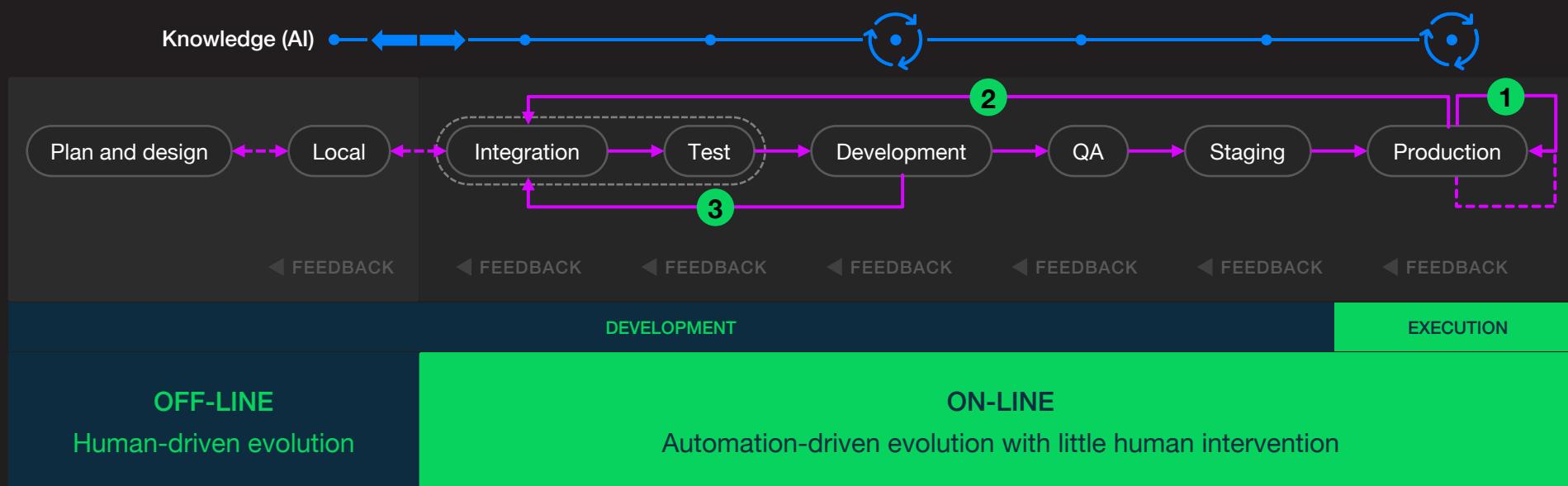
Config 1: \$0.119 per hour (2x/month)

Config 2: \$0.060 per hour (1x/month)

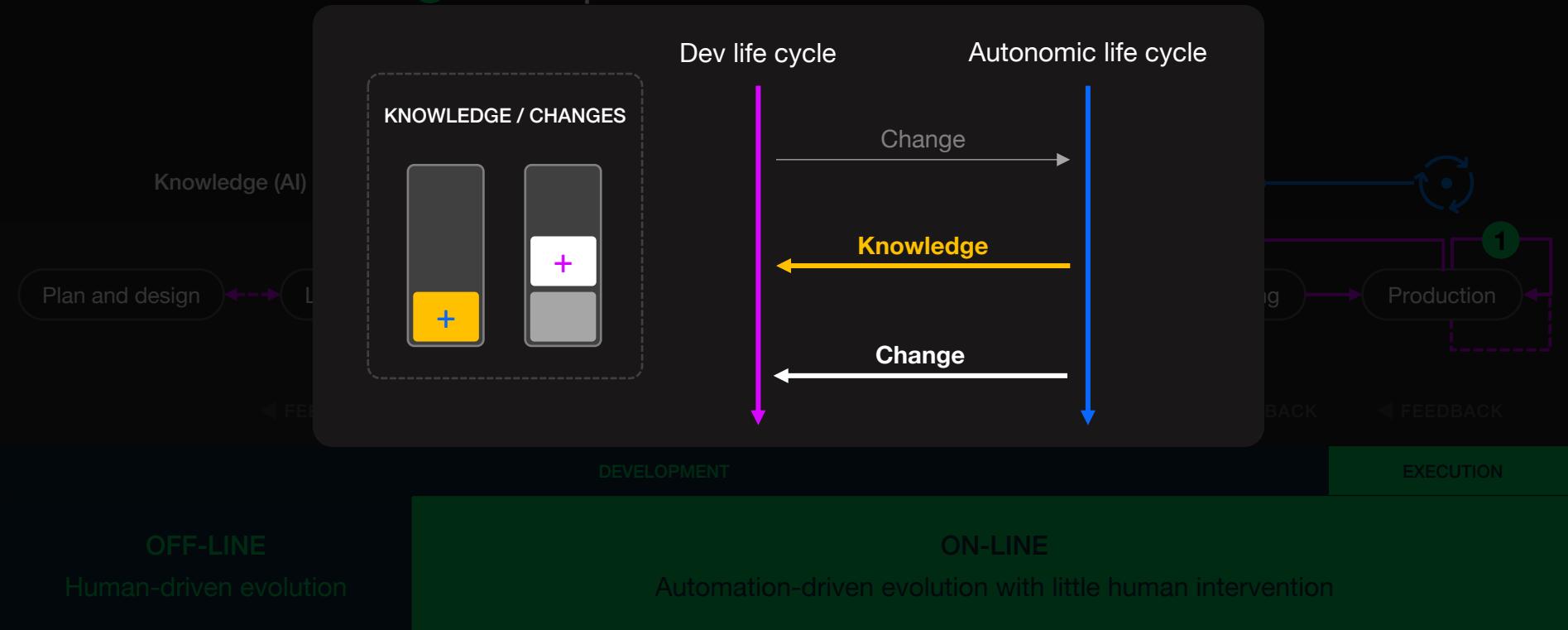
Costs**Automated Search Space Exploration Through Continuous Experimentation**

Not published yet

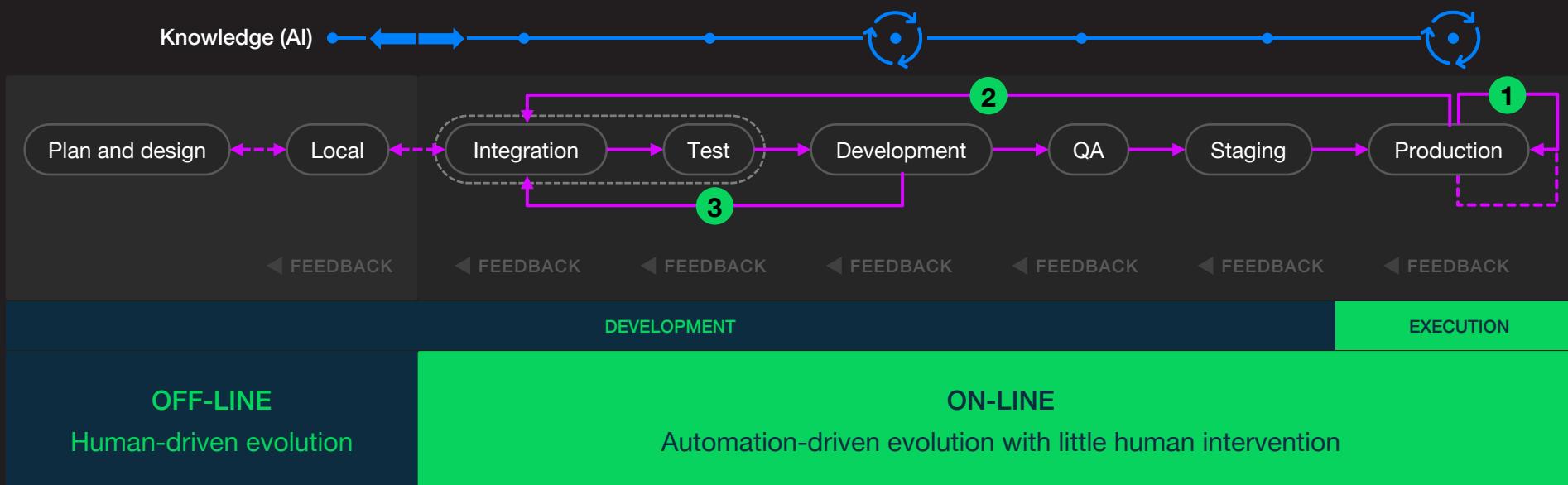
- 1 Self-management
- 2 Self-evolution
- 3 Self-improvement



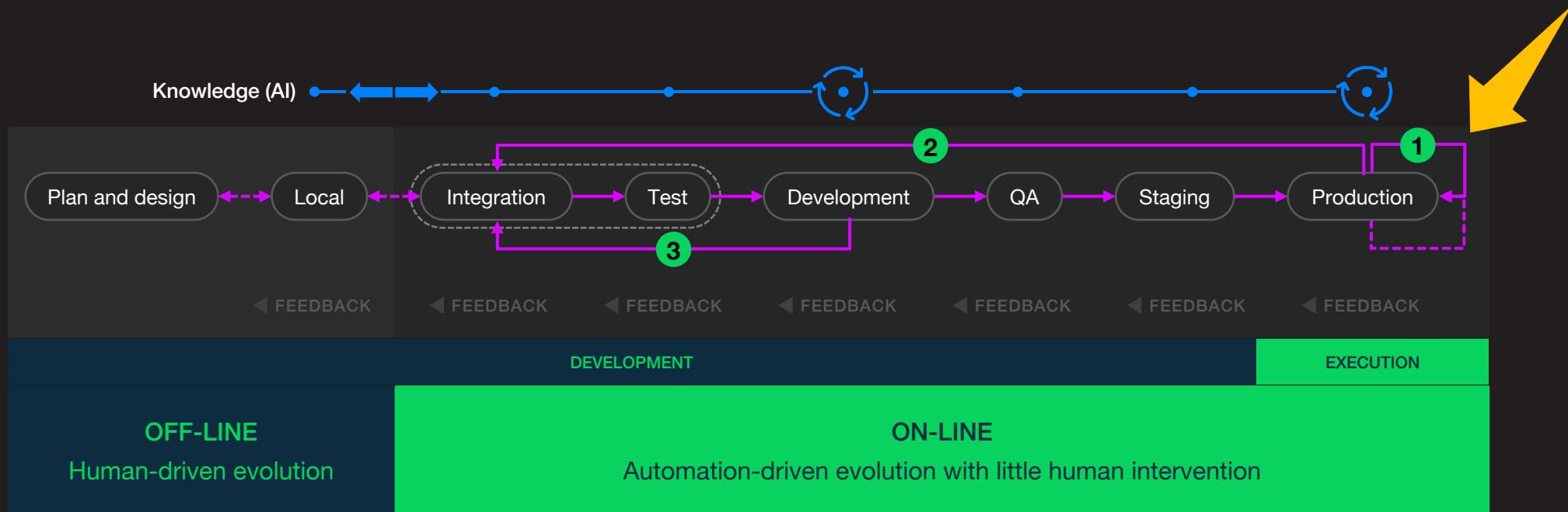
- 1 Self-management
- 2 Self-evolution
- 3 Self-improvement



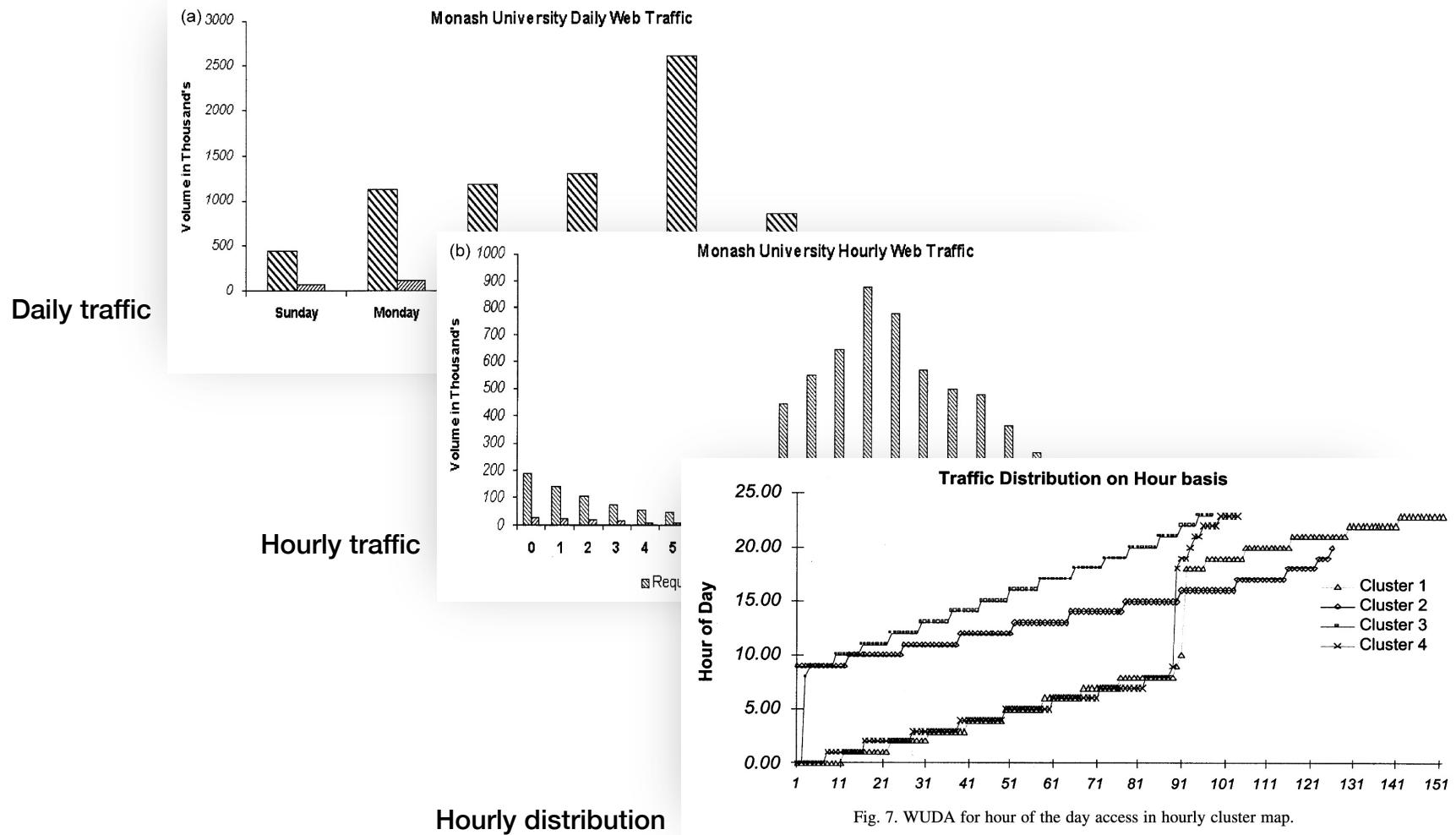
- 1 Self-management
- 2 Self-evolution
- 3 Self-improvement



- 1 Self-management
- 2 Self-evolution
- 3 Self-improvement



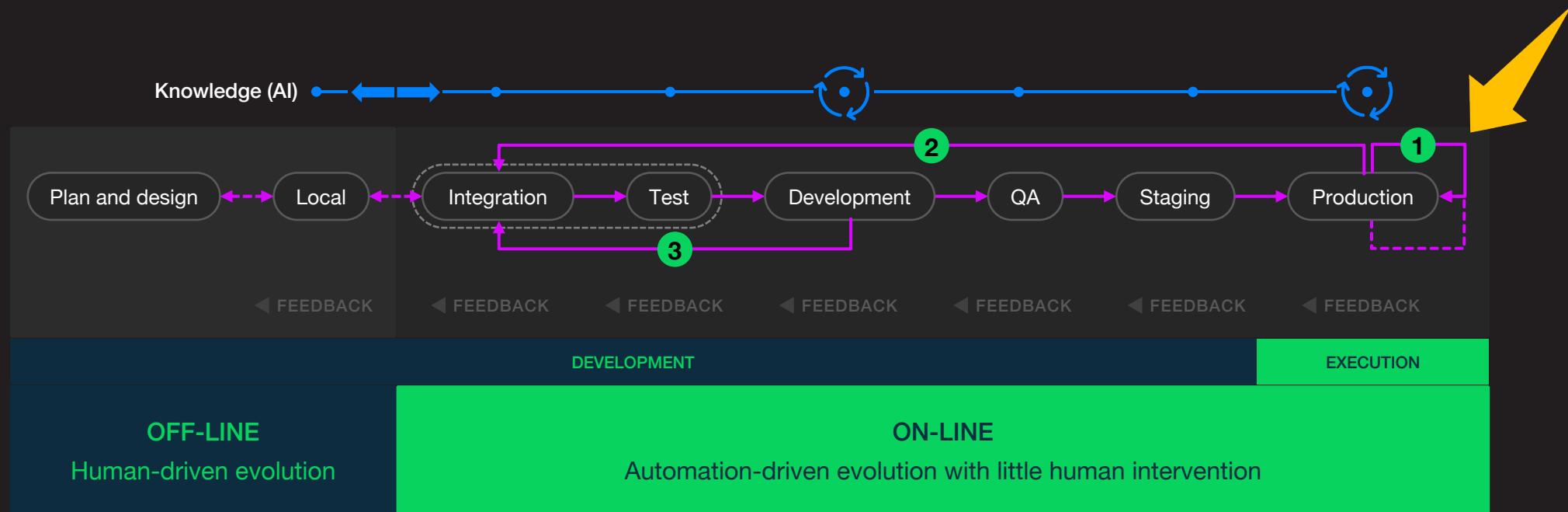
Example



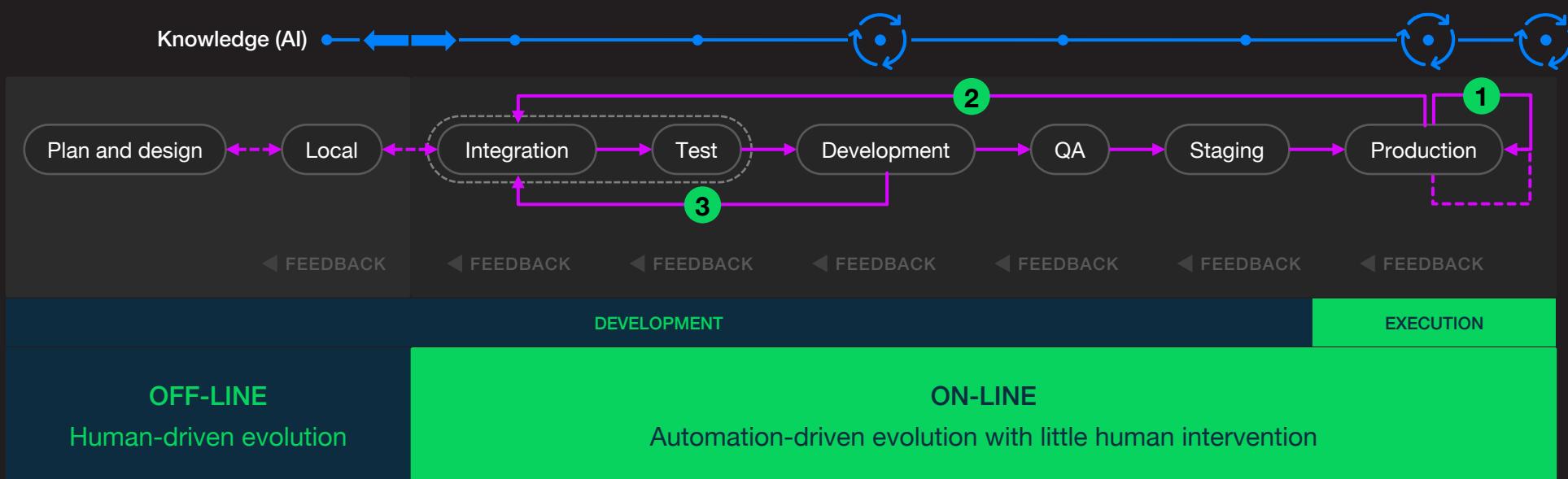
Web Traffic Mining and Analysis

Wang et al. "Web Traffic Mining and Analysis." 2004

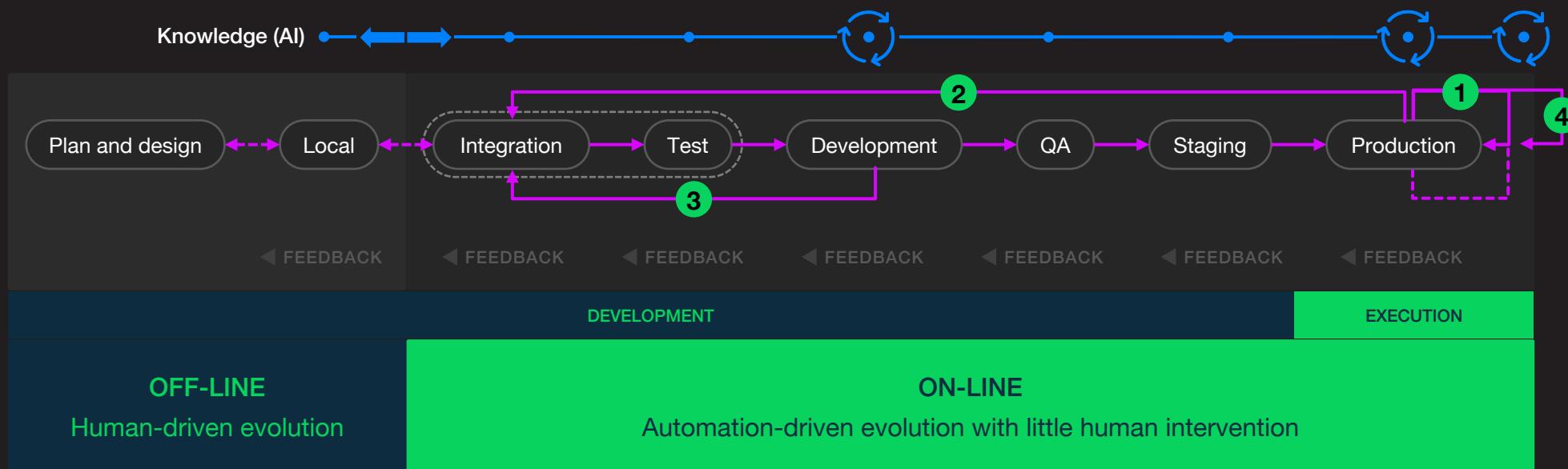
- 1 Self-management
- 2 Self-evolution
- 3 Self-improvement



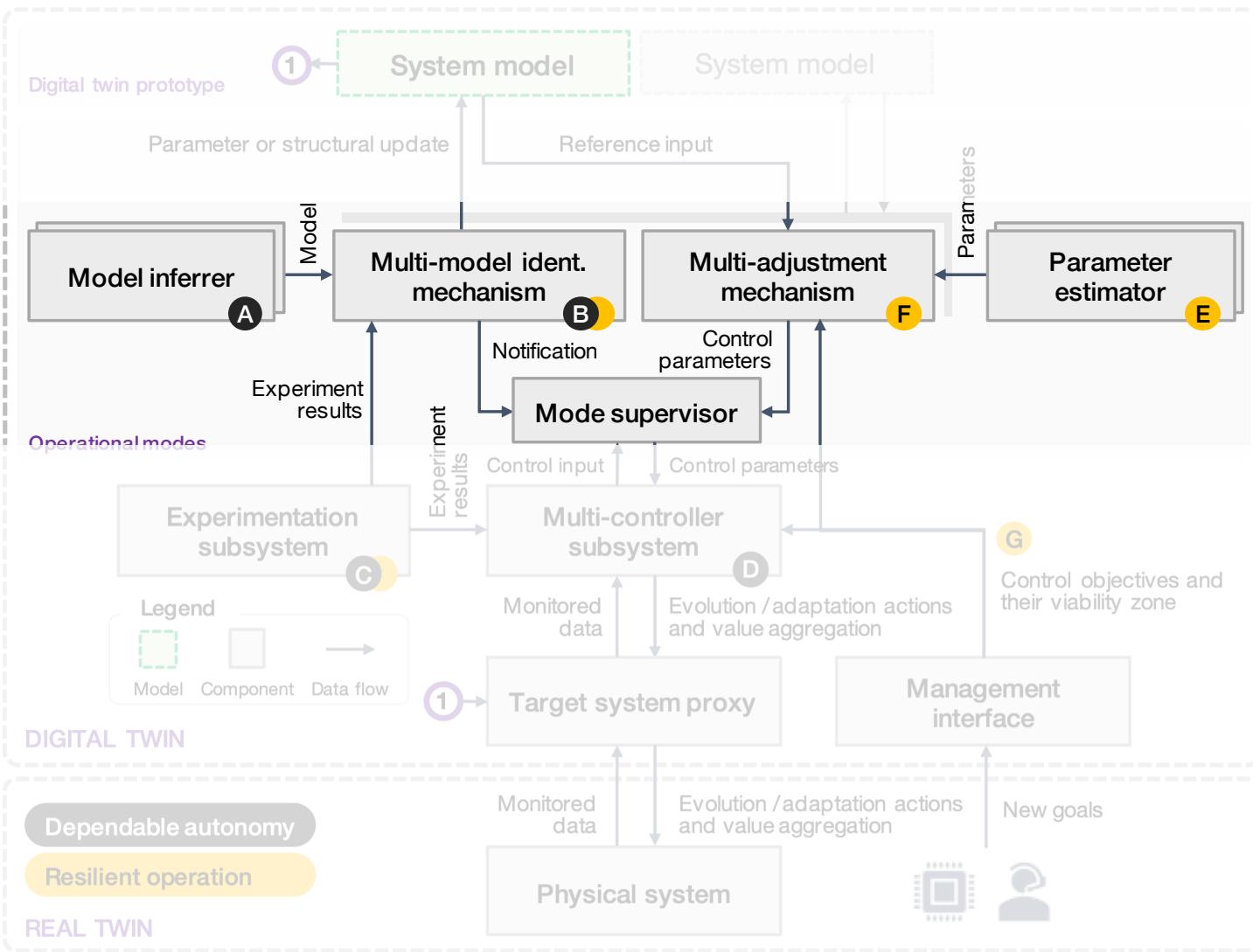
- 1 Self-management
- 2 Self-evolution
- 3 Self-improvement



- 1 Self-management
- 2 Self-evolution
- 3 Self-improvement
- 4 Self-regulation



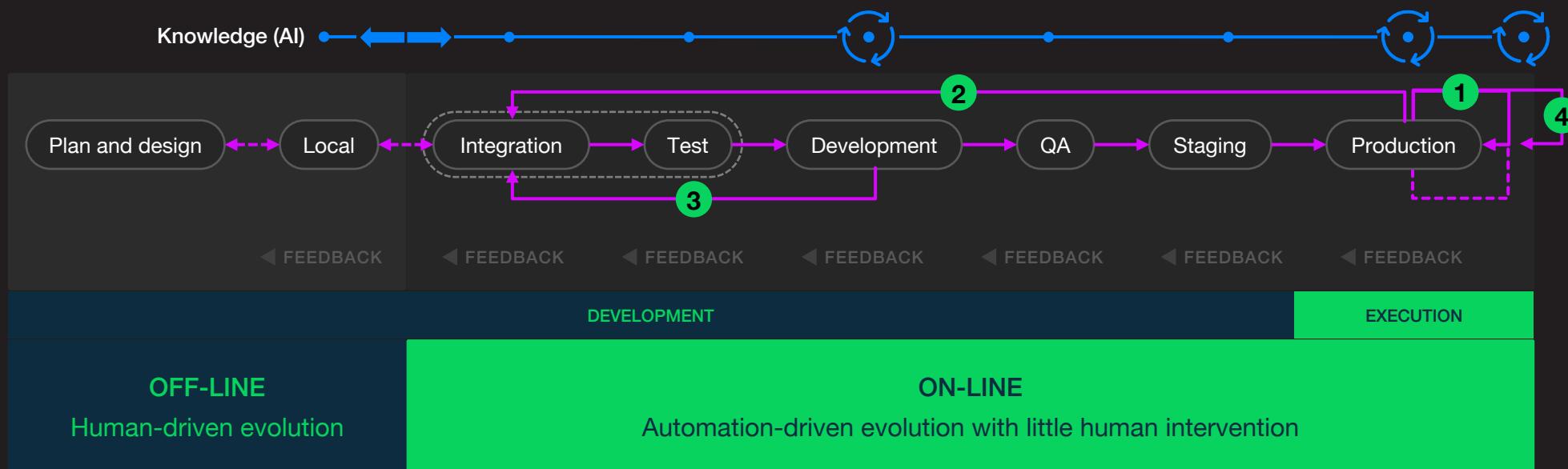
Example



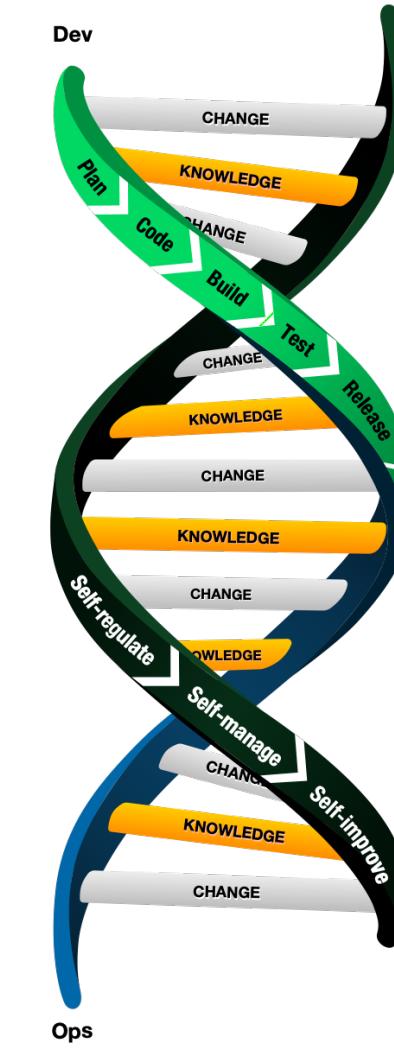
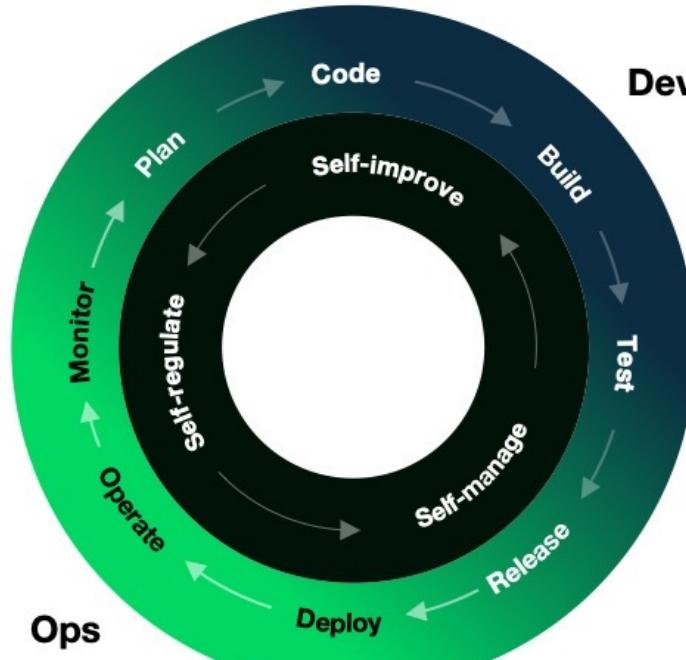
Two Operational Modes of an Autonomic Manager

Rivera and Jiménez et al. "Designing Run-time Evolution for Dependable and Resilient Cyber-Physical Systems Using Digital Twins." 2021

- 1 Self-management
- 2 Self-evolution
- 3 Self-improvement
- 4 Self-regulation



Autonomic and continuous software evolution process



4 Pathways to Autonomic Software Evolution Through Digital Twin

Thank you!

Miguel Jiménez, Luis F. Rivera, Norha M. Villegas,
Gabriel Tamura, Hausi A. Müller

#CXEttechconf

